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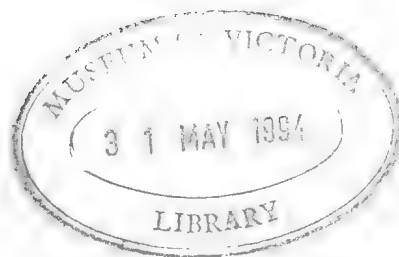
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*Oratosquilla septemdentata* n.sp.  
(Crustacea: Stomatopoda: Squillidae),  
a New Species of Deep Water Stomatopod  
from Halmahera, Indonesia

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**ABSTRACT.** *Oratosquilla septemdentata* n.sp., is a new species of stomatopod from Halmahera. It is unique in *Oratosquilla* for bearing seven teeth on the raptorial claw. Although it corresponds to none of the current species groups within the genus, it comes closest to species of the *Oratosquilla woodmasoni* species group. *Oratosquilla septemdentata* is the only species of this genus known to occur in depths exceeding 400 m.

AHYONG, S., 1994. *Oratosquilla septemdentata* n.sp. (Crustacea: Stomatopoda: Squillidae), a new species of deep water Stomatopod from Halmahera, Indonesia. Records of the Australian Museum 46(1): 1-4.

During examination of unidentified stomatopods in the collections of the Australian Museum, two specimens collected from Halmahera in deep water, simply labelled "*Oratosquilla* sp." were found. Their dissimilarity to any known stomatopod prompted a description of this new species.

The type material is deposited in the Australian Museum, Sydney.

Total length is measured on the midline, from the anterior margin of the rostral plate to a line between the apices of the submedian teeth of the telson. Carapace length is measured along the midline and excludes the rostral plate. The corneal index (given as the carapace length divided by the cornea width multiplied by 100) follows the convention of Manning (1971).

*Oratosquilla* Manning, 1968

*Oratosquilla septemdentata* n.sp.

Fig. 1

**Type material.** HOLOTYPE, male, total length 81.3 mm (AM P41484), inner basin, Teluk Kau, Halmahera, Indonesia, 0°55'N 127°49'E, 460 m, 1.8 m beam trawl, Te Vega Expedition, coll. J. Bennett, Stn 56, 26 Sept. 1963. PARATYPE, male, total length 83 mm, type locality (AM P41839).

**Diagnosis.** Rostral plate length and breadth equal, lacking median carina; apex rounded; eye large, cornea set obliquely on stalk; corneal index 349; anterior margin of ophthalmic somite 3 pointed; anterior width of

carapace exceeding half median length; median carina of carapace poorly defined; anterior bifurcation of median carina of carapace absent; raptorial claw with 7 teeth, dorsal ridge of carpus tuberculate (2-3 tubercles), inferodistal margin of outer face of merus produced to a blunt projection; mandibular palp 3-segmented; epipod on first 4 maxillipeds; lateral processes of exposed thoracic somites bilobed; abdominal carinae armed on the following somites: submedian 5-6, intermediate 3-6, lateral 1-6, marginal 1-5; telson denticles: 4-5 submedian, 8-9 intermediate, 1 lateral; proximal segment of uropodal exopod 1.3 times length of distal; inner spine on basal prolongation of uropod with rounded lobe on outer margin, proximal margin of spine slightly concave.

**Description.** Size small to medium; total length of

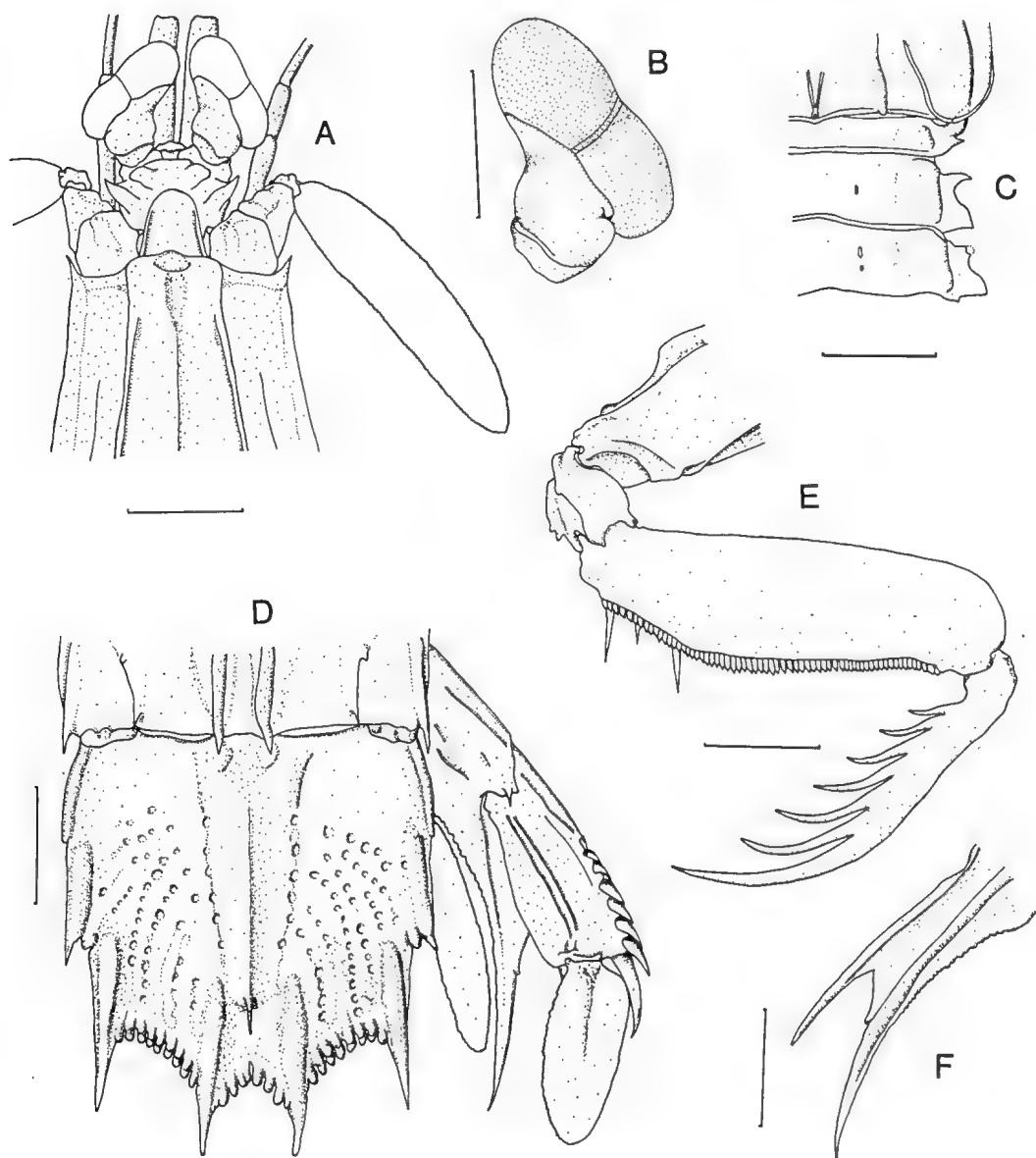
adults less than 83mm. Body appearing smooth and polished under magnification.

Eye (Fig. 1B) moderate to large with cornea bilobed and set obliquely on stalk. Eyes not extending beyond first segment of antennular peduncle. Corneal index 349. Ocular scales inclined laterally, separated mesially and subtruncate. Anterior margin of ophthalmic somite with three points.

Rostral plate length and breadth equal (Fig. 1A). Lateral margins convergent; apex rounded; median carina absent.

Antennal scale long and slender, 0.8 times the carapace length.

Carapace narrowing anteriorly. Anterior width of carapace exceeding half median length. Anterolateral spines strong, extending just beyond base of rostral plate. Median carina poorly developed. Anterior



**Fig. 1.** *Oratosquilla septemdentata*, holotype, male, AM P41484, total length 81.3 mm, Halmahera: A, anterior portion of body; B, right eye; C, lateral processes of fifth, sixth and seventh thoracic somites; D, telson and right uropod; E, raptorial claw; F, basal prolongation of right uropod, ventral view. Setae have been omitted. Scale bars in A,C,D,E,F = 5 mm; B = 3 mm.

bifurcation of carina absent. A longitudinal depression lies posterior to rostral plate in normal position of anterior bifurcation (Fig. 1A). Posterior bifurcation of median carina well developed. Posterolateral angles broadly rounded; median spinule on posterior margin of carapace.

Mandibular palp 3-segmented; epipod present on first 4 maxillipeds. Ischium of fifth maxilliped armed with ventrally directed spine on posterior margin.

Dactylus of the raptorial claw (Fig. 1E) armed with 7 teeth; outer margin broadly curved, moderately sinuous proximally. Inferior margin of propodus pectinate with 3 movable spines. Dorsal ridge of carpus tuberculate (2-3 tubercles). Inferodistal angle on outer face of merus produced to a blunt projection.

Exposed thoracic somites (Fig. 1C) with unarmed submedian and intermediate carinae. Submedian carina poorly developed; incomplete. Lateral processes of fifth, sixth and seventh thoracic somites bilobed. Lateral processes of fifth somite with anterior lobe produced into a slender spine directed anterolaterally; posterior lobe acute and much smaller. Lateral processes of sixth somite strongly bilobed: anterior lobe spinous and moderately recurved posteriorly; posterior lobe triangular to subquadrate. Lateral processes of seventh somite with anterior lobe small and blunt; posterior lobe large and triangular to subquadrate.

Eight carinae present on anterior 5 abdominal somites. Six carinae present on sixth abdominal somite. Abdominal carina posteriorly spined on the following somites: submedian carina 5-6, intermediate carina 3-6, lateral carina 1-6, marginal carina 1-5.

Telson (Fig. 1D) flattened, length 1.1 times width. Prelateral lobe subequal in length to margin of lateral tooth. Dorsal surface of telson ornamented with curved rows of shallow pits. Median carina posteriorly armed. On posterior margin of telson, denticles present as follows: 4-5 submedian; 8-9 intermediate; 1 lateral. Ventral surface with low postanal keel.

Uropod slender (Fig. 1D,F); lobe on outer margin of inner spine of basal prolongation small and rounded, proximal margin slightly concave. Inner margin of inner uropodal prolongation sinuous; inner prolongation longer than outer. Lateroventral surface of sixth abdominal somite with small spine anterior to uropodal articulation. Proximal segment of uropodal exopod 1.3 times longer than distal. Outer margin of proximal segment of uropod with 8 movable spines.

**Colour in alcohol.** A rectangular concentration of dark pigment is present medially on the second abdominal somite. The posterior margin of the telson and the distal half of the uropods bear dark pigmentation. Colours are otherwise faded to creamy-yellow in the present specimens.

**Measurements.** Holotype male 81.3 mm long; carapace length 17.4 mm; corneal index 349; rostral plate length 3.0 mm, width 3.1 mm; telson length 18.2 mm, width 16.3 mm.

**Etymology.** The specific name is derived from the Latin *septem* and *dentis* referring to the seven-toothed raptorial claw.

**Remarks.** *Oratosquilla septemdentata* differs from other species presently assigned to *Oratosquilla* in bearing seven teeth on the raptorial claw. Whilst the most striking feature of *O. septemdentata* is the dentition of the raptorial claw, the condition of the median carina of the carapace is significant. In other species of *Oratosquilla*, the median carina of the carapace is almost always well developed despite the presence or absence of the anterior bifurcation. In *O. septemdentata*, although the medial region of the carapace is elevated and peaks along the midline, the median carina is only barely distinguishable. While stage of growth may affect resolution of structures such as the median carina, as in post larvae and juveniles, the present specimens appear to be adults as suggested by the well-developed penes. The rudimentary condition of the median carina is likely to be a normal character in adults of this species.

Within *Oratosquilla*, *O. septemdentata* corresponds to none of the current species groups though it most closely resembles species of the *O. woodmasoni* species group (Manning, 1978). As in other species of the *O. woodmasoni* group, the anterior carapace width exceeds half the carapace length, the body surface is smooth, the carpal crest of the raptorial claw is tuberculate and the anterior bifurcation of the median carina of the carapace is absent (as in some members of this group). However, the inferodistal spine on the outer merus of the raptorial claw is unarmed resembling species of the *O. gonypetes* group (Manning, 1978) and the anterior margin of the ophthalmic somite is three-pointed rather than broadly curved, with or without a median spinule as is characteristic of the *O. woodmasoni* group. All present members of the *O. woodmasoni* group have six teeth on the raptorial claw. This is the only species in the genus bearing seven teeth on the raptorial claw. Further study may indicate separate generic status, but at this stage it would be premature to erect a new genus based essentially on what may be an odd apomorphic character.

Most species of *Oratosquilla* inhabit the shallow sublittoral zone though *O. perpensa* (Kemp, 1911) has been taken from 73-91.5 m (Manning, 1978) and *O. massavensis* (Kossmann, 1880) at 100 m (Makarov, 1971). *Oratosquilla septemdentata* appears to be a deep water form as no other oratosquillid is known to occur below 400 m (Manning, 1991).

**Distribution.** Known only from the type locality.

**ACKNOWLEDGMENTS.** I wish to thank Dr R.B. Manning (Smithsonian Institution) for providing helpful information and Dr P. Berents (Australian Museum) for reviewing the manuscript. Special thanks to Mr R.T. Springthorpe (Australian Museum) for his invaluable comments and criticisms during preparation of the manuscript.

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Accepted September 24, 1993

## **Evaluation of Potential Sapphire Source Rocks within the Catchments of Kings Plains Creek and Swan Brook, near Inverell, New South Wales**

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**ABSTRACT.** Basaltic and volcanoclastic rocks in the East Central Volcanic Province, New South Wales, are potential sources of the alluvial sapphires being mined in the New England Gem Fields. The associated drainage catchment areas generally contain sapphire, but only four major catchments contain rich deposits: Frazers, Kings Plains, Reddestone and Marowan. These catchments are thus the most likely targets for sapphire source rocks. The Mount Buckley basalt flows and intrusives divide Kings Plains Creek and Swan Brook catchment areas for alluvial sapphire. Whole-rock analyses show mostly alkaline to strongly alkaline types becoming more undersaturated with time. The top flows are predominantly basanite and nepheline hawaiites whilst the lowest are predominantly alkali olivine basalts and hawaiites. Ultramafic xenoliths in several flows suggest rapid movement from upper mantle levels. Marked variation in major and trace elements between groups of flows suggests that flows were intercalated from different levels. Variation diagrams do not distinguish the 32 to 39 Ma sapphire-associated eastern Central Province basalts from the 19 to 23 Ma sapphire-barren western Central Province alkali-basalts. The Central Province compositional fields also overlap the volcanic provinces in north-eastern Australia, known to contain sapphire (Atherton, McBride and Chudleigh), as well as those believed to be barren. These Australian compositional fields also overlap the corundum-bearing and corundum-less fields for the south-east Asian volcanic provinces. Major and minor element chemistry of basaltic rocks is not a useful exploration tool for discriminating sapphire-bearing from sapphire-barren volcanic provinces, nor for recognising potentially high-grade areas within a sapphire-bearing province. This suggests that basaltic magmas are not the sapphire parent rocks, but only one of their potential carriers.

COENRAADS, R.R., 1994. Evaluation of potential sapphire source rocks within the catchments of Kings Plains Creek and Swan Brook, near Inverell, New South Wales. *Records of the Australian Museum* 46(1): 5-24.



Corundum-bearing gem fields have long been associated with areas of basaltic volcanism (Dunstan, 1902). Such gem fields include New England (sapphire) and Anakie (the world's best green and golden yellow sapphire) in Australia (MacNevin, 1972; Broughton, 1979; Coenraads, 1990), and others in south-east Asia, China, Colombia and Africa (see Coenraads, 1992 for detailed list). Sapphires may be found in matrix in basic dykes of alkaline affinity at Yogo Gulch near Utica, Montana, USA (Brownlow & Komorowski, 1988), and at Loch Roag on the Isle of Lewis, Scotland (Jackson, 1984).

Basalts associated with corundum-bearing gemfields are generally nepheline normative and highly alkaline types, showing low SiO<sub>2</sub> and high MgO & TiO<sub>2</sub> (Vichit *et al.*, 1978; Barr & MacDonald, 1981). Coenraads *et al.* (1990) have shown, by means of dating zircon inclusions in New England sapphires, that corundum formation there is probably the same age as the associated basalts. Zircon formation dates in other provinces (Sutherland & Kinny, 1990) suggest that corundum formation may also be considerably older.

Although sapphires are found, in varying quantity and quality, in streams and rivers draining many Cenozoic-Mesozoic "lava field" provinces in eastern Australia, (Spencer, 1983), there has only been economic recovery from two provinces, the Central Province in northern New South Wales (the New England field) and the Hoy Province in central Queensland (the Anakie field).

In recent years, the New England field has contributed over 50% of Australia's sapphire production which, although not well documented, probably exceeds 5 million carats annually (T.J. & P.V. Nunan Pty Ltd, unpublished data, 1989).

### Volcanism in the Central Province

The Central Province, in north-eastern New South Wales (Fig.1), is one of a number of Mesozoic-Cenozoic intraplate volcanic provinces which form a discontinuous belt stretching over a distance of 4400 kilometres and up to 300 kilometres wide, within or adjacent to the eastern Australian highlands (Johnson, 1989).

The Central Volcanic Province, comprising Tertiary basaltic volcanics, intrusives and minor sediments, locally overlies and intrudes Devonian to Triassic volcanics, metasediments and plutonics of the Woolomin-Texas Block of the New England Fold Belt (Leitch, 1974). The basaltic rocks yield potassium-argon ages of 19 to 39 Ma (see Coenraads *et al.*, 1990, Table 1; Appendix II, sample B14).

The lavas predominantly include alkali olivine basalts, basanites, hawaiites and nepheline hawaiites (Wilkinson, 1962; Wilkinson, 1966; Binns, 1969; Binns *et al.*, 1970; Duggan, 1972; Wilkinson, 1973; Wilkinson & Duggan, 1973; Street, 1974; McKay, 1975; McQueen, 1975; Barron, 1987; W.J. Stroud, J.K. Karaolis & R.R. Coenraads, unpublished data), and give a database of 114 analyses. Tholeiites occur near Inverell (Duggan, 1972;

Wilkinson & Duggan, 1973). and various volcanoclastic rocks have been reported (Lishmund & Oakes, 1983; Sutherland, 1985; Temby, 1986; Barron, 1987). The latter occur extensively in the Inverell-Glen Innes region, usually situated at or near the base of the volcanic pile (Brown & Pecover, 1986a,b; Brown, 1987; Pecover, 1987; Pecover & Coenraads, 1989), and some contain sapphire (Pecover & Coenraads, 1989).

Based on age, structural and drainage data, the Central Province shows at least two distinct periods of volcanic activity – one at 32 to 39 Ma and the other at 19 to 23 Ma (Coenraads, 1990), and based on zircon age data (Sutherland *et al.*, 1991) there may be at least five periods of volcanism. The older episodes forming the eastern portion of the Central Province are sapphire-bearing whereas the youngest, partly tholeiitic, western episode is essentially barren.

Coenraads (1990) summarises the geological and geomorphic evolution of the Central Volcanic Province as follows.

i) Pre-volcanic doming, and/or uplift along the Great Divide altered the pre-volcanic topographic surface producing high ground and radial drainage centred on the East Central Province. This was accompanied by faulting and the opening of deeply penetrating north-north-west trending fractures sub-parallel to the pre-existing fabric of the New England Fold Belt.

ii) Injection of breccias and explosive eruption of pyroclastic material took place prior to 38 Ma, forming a blanket of volcanic debris, (some sapphire-bearing), on the pre-basaltic topography.

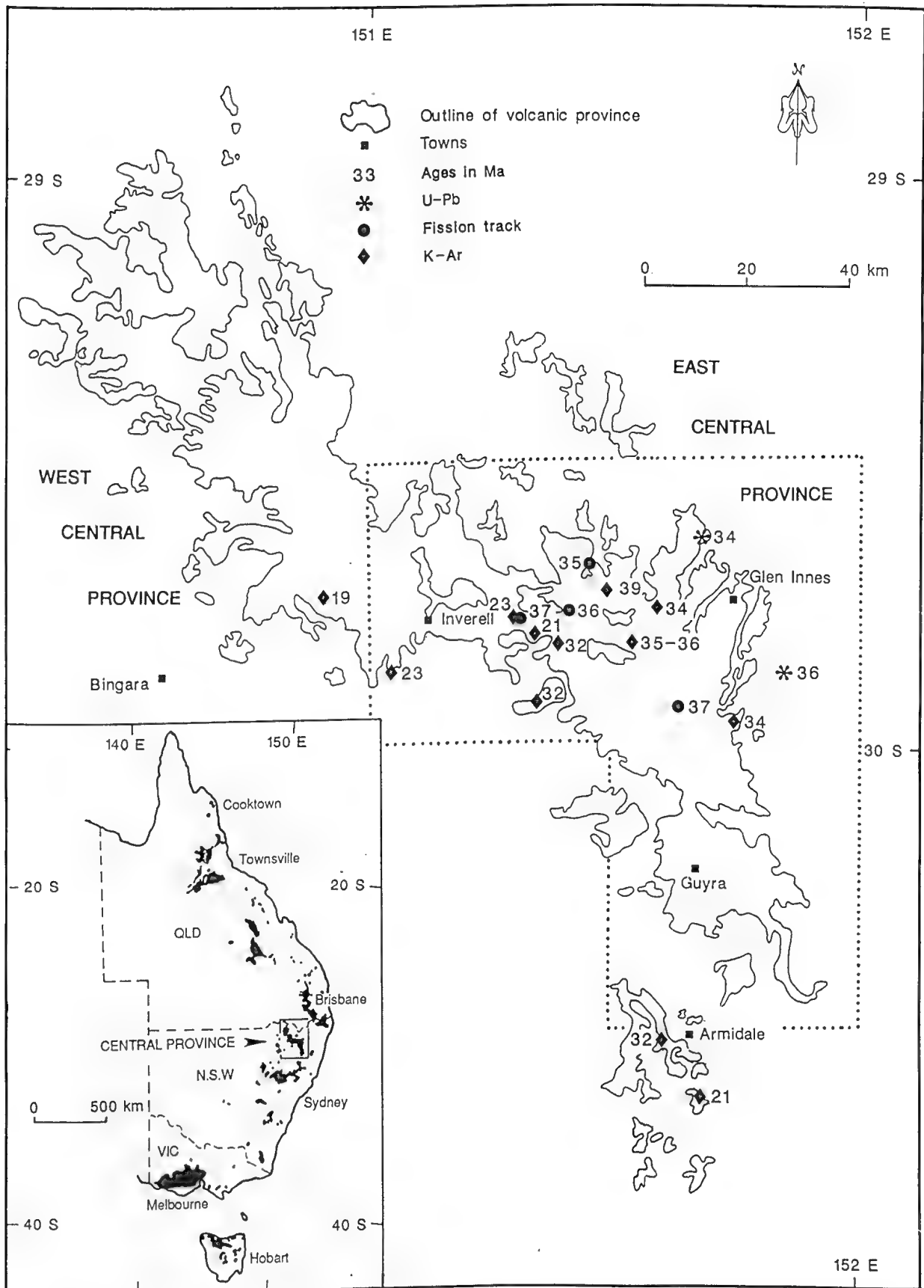
iii) Explosive volcanic eruption continued, as well as basalt extrusion, with a general decrease in the amount of explosive activity with time. Early basaltic lavas flowed down valley systems and may be found directly on basement rocks in places.

iv) Major effusive basaltic eruptions took place along the fractures at about 39 to 32 Ma, producing a "lava field" with an overall south-south-east/north-north-west elongation and a shield centred on Maybole.

v) Erosion and reworking, particularly of the less resistant volcanoclastic rocks, took place over some 10 million years forming alluvial concentrations of sapphire and zircon, and also diamonds (from local sources).

vi) The next phase of volcanism, also controlled by south-south-east/north-north-west trending planes of weakness, was further west. Basaltic eruptions grading from tholeiitic to alkaline formed the West Central Province and some volcanics south and west of Armidale between 23 to 19 Ma. The basalts covered the Tertiary alluvium, forming deep leads. East of the East Central Province these Tertiary alluvials have been removed due to the westward migration of the Great Escarpment and the lack of a protective basalt cap. Pockets remain however to the north-west, west and south.

vii) The growth of the West Central Province deflected the west and north-westerly flowing drainage system radiating from the Maybole high and developed a radial drainage pattern centered on the Delungra-Mount Russell areas.



**Fig.1.** Location of the Central Volcanic Province in north-eastern New South Wales. The province comprises an older sapphire-bearing East Central Province and a sapphire-barren West Central Province. The inset shows Mesozoic-Cenozoic volcanic provinces which form a discontinuous band within or adjacent to the Eastern Australian Highlands. The portion of the Central Province outlined is enlarged in Figure 2.

viii) Since the Tertiary there has been only minor westward migration of the Great Divide (Coenraads & Ollier, 1992). However headward erosion of the radial streams of the Central Province volcanic high has created some classic captures. Retreat, possibly of the order of five kilometres, along some of the streams has cut into and/or topographically inverted basalt filled palaeodrainage.

## Aim

This contribution aims to:

1. Differentiate the Central Province into catchment areas along drainage divides or interfluvies.
2. Classify the catchments, based on the watershed analysis and drainages from which sapphires have been recovered, as economic (worthy of further exploration), or non-economic. This allows definition of exploration targets, for both alluvial deposits and their potential source rocks.
3. Evaluate potential sapphire source rocks within one of the defined economic areas. Major element and trace element data, together with field data, will be used to test for differences between sapphire-bearing and sapphire-barren parts of the Central Province.
4. Compare lava compositions of the Central Province with those of other sapphire and non-sapphire bearing volcanic provinces in north-eastern Australia and south-east Asia.

## Method

### 1. Watershed analysis of the Central Province.

The watershed analysis was carried out at the 1:100,000 scale covering the Inverell, Glen Innes and Guyra sheets. Lines following the highest topographic points or water divides were drawn on the 1:100,000 topographic sheets dividing them into catchment areas shown in Figure 2. Each catchment is named after the principal creek or river flowing in it. Material cannot be moved across a water divide by the normal process of erosion; it can only move within its watershed downslope from its original location. Conversely, the source rocks for a sapphire deposit located within a particular catchment must be, or have been, located upslope within that catchment area.

In some areas source rocks may no longer exist in a catchment area. At a Public Fossicking Area, formerly a mining area, (grid reference GR:630188, Glen Innes 1:25,000 sheet), sapphires and zircons occur in alluvium trapped in cracks and crevasses in Permian granodiorite whilst former basaltic and/or volcanoclastic rocks have been completely eroded.

The watershed analysis was used to define distinct catchment areas which could then be superimposed on maps showing economic sapphire deposits (Fig.2).

**2. Definition of specific catchment areas for sapphire exploration.** Although sapphire is ubiquitous in almost all East Central Province drainages, only some contain mineable to very rich deposits (MacNevin, 1977; T.J. Nunan & J. McPhee personal communication, 1988). Using this knowledge, drainages with significant sapphires were tabulated by Coenraads & Lawrence (1989) and the extent of the catchments of these economic deposits is presented in Figure 2.

Four catchment areas within the Central Province are classed as economic, and worthy of greater exploration for alluvial deposits and for their potential source rocks, i.e. the Frazers, Kings Plains, Reddestone and Marowan catchments.

The geology and setting of the alluvial sapphire deposits, in particular the important Kings Plains Creek and Reddestone Creek deposits currently held by T.J. & P.V. Nunan (Great Northern Mining), are discussed by Coenraads (1990) and Pecover (1992).

**3. Source rock evaluation.** Within the four defined catchment areas, outcrops of basalt and volcanoclastic rocks have been mapped and compiled at the 1:25,000 and 1:100,000 scales by Stroud (1989), Willis (1989) and Brownlow (1989).

The basalts appear to have flowed down and filled palaeovalleys, the axes of which have been mapped by Coenraads (1990).

The volcanoclastic rocks are typically red-brown in colour with numerous angular fragments of basement rocks or basalt and are highly altered to clay. They often appear between basalt flows and the underlying basement and probably result from initial explosive volcanism from feeder dykes, such as at Braemar (Pecover & Coenraads, 1989). The volcanoclastic rocks appear to have been quite fluid precursors to the basalt flows as dewatering structures may be observed in directly overlying flows.

Whole-rock chemistry of the volcanoclastic rocks, as potential sapphire source indicators in the economic catchments, is not considered useful because all observed volcanoclastic rocks are weathered to clays. Additional complications include; unknown percentage contamination by country rocks during explosive emplacement; unknown original lava type; and unknown amount of reworking. These rocks are discussed by Pecover & Coenraads (1989), chemical analyses and an attempt to unravel their origin is presented by Barron (1987), and their residual heavy minerals are described by Coenraads (1990).

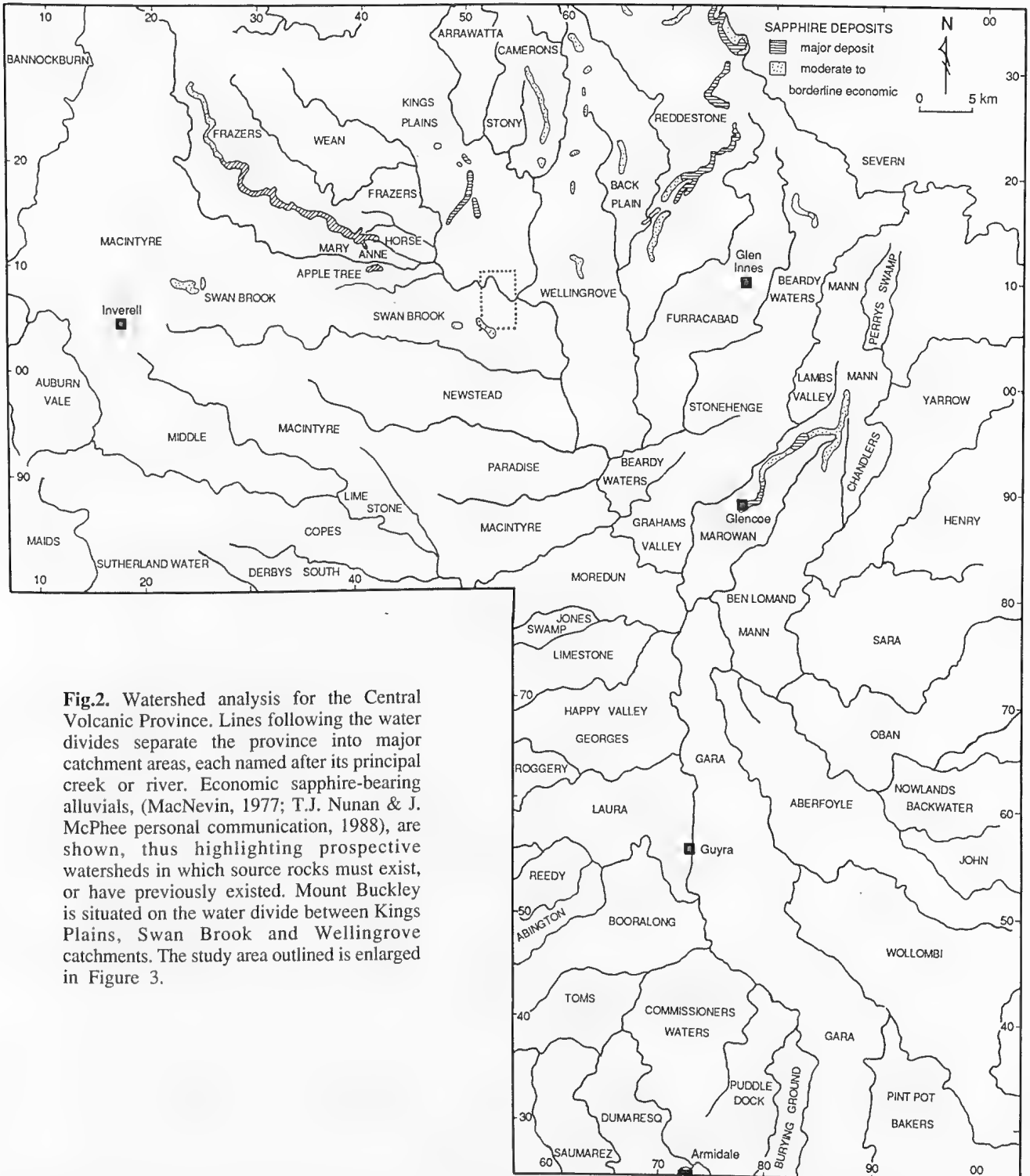
The area chosen for detailed investigation (Figs 2, 3) includes the water-divide between Kings Plains Creek, to the north, and Swan Brook, to the south, as both systems are mined for alluvial sapphires. Mount Buckley, the highest point along the divide, is a logical place for a representative cross section of Central Province volcanic rocks, being likely to contain possible sapphire source rocks and exposing the thickest vertical section.

The countryside is smooth and rolling with the grassed hills being used primarily for grazing. Outcrop is

restricted to isolated areas and the determination of continuity between exposures is difficult. The absence of tall vegetation cover, however, permits observation of subtle breaks in slope both on air photo and on the ground. Each change in gradient was assumed to represent a contact between flow units and upon inspection, the break in slope was represented as a small cliff or ungrassed outcrop from which a sample could be taken. The grassed top of the underlying flow was then followed down hill to the next break in slope where another sample could be taken.

Thicknesses and dips of individual flows could not be determined, although the appearance (grainsize, vesicles, xenoliths, phenocrysts etc.) of the hand specimen was often distinctive between sample sites (see Appendix II).

Compared with the ideal of using a vertical drill hole, the above technique is poor and considering the influences of pre-volcanic topography, it is possible that a flow may be resampled at a lower level. These possibilities must be borne in mind when interpreting the data.



**Fig.2.** Watershed analysis for the Central Volcanic Province. Lines following the water divides separate the province into major catchment areas, each named after its principal creek or river. Economic sapphire-bearing alluvials, (MacNevin, 1977; T.J. Nunan & J. McPhee personal communication, 1988), are shown, thus highlighting prospective watersheds in which source rocks must exist, or have previously existed. Mount Buckley is situated on the water divide between Kings Plains, Swan Brook and Wellinggrove catchments. The study area outlined is enlarged in Figure 3.

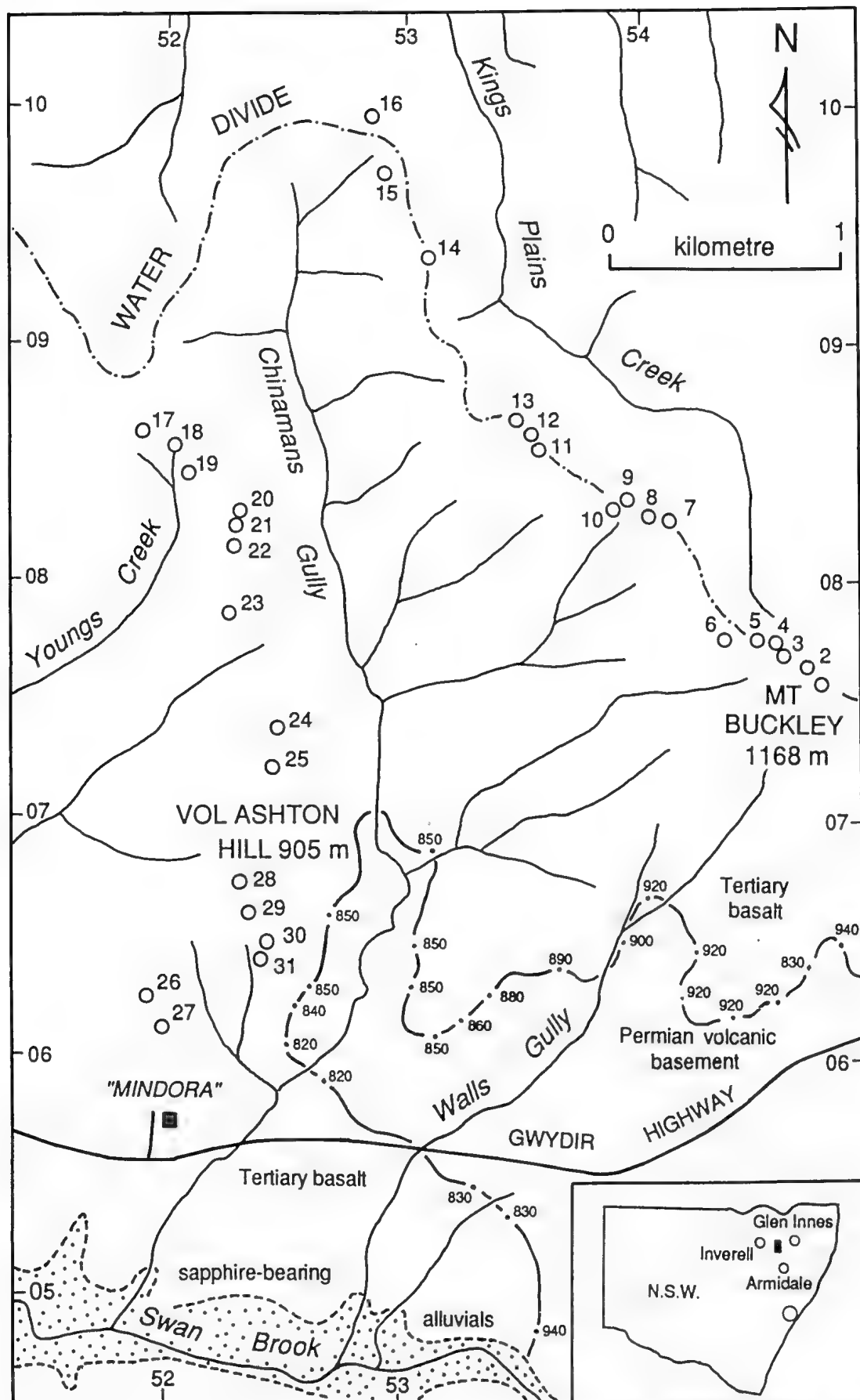


Fig.3. Location of basalt sample localities at Mount Buckley. Elevation and grid references on the Elsmore and Sapphire 1:25,000 topographic sheets are listed in Table 1 (Appendix I). The water divide between the Swan Brook and Kings Plains catchments, and the position and elevation in metres of the contact between Tertiary basalt and the underlying Permian volcanic basement are also shown.

## The Mount Buckley Basalts

The 31 samples collected (Fig.3) represent some 300 metres of section. From sample B1 at the top of Mount Buckley (Matheson Trig Station elevation 1168 m GR:547077 Inverell 1:100,000), the traverse followed the ridge down to the north-west, around the head of Chinamans Gully, GR:525100 then south along a spur to Vol Ashton Hill, GR:523069, and finally down a spur to the lowermost flow, B27, resting on basement behind "Mindora" shearing sheds (840 - 860 m elevation, GR:519059). A further four samples B28 to B31 were collected from another spur off Vol Ashtons Hill, GR:524064, with the lowermost flow, B31, also resting on basement.

Flow B14 was chosen as the most suitable for K/Ar dating as it showed neither glassy groundmass nor significant alteration. It yielded an age of  $39.0 \pm 0.3$  Ma. (F.L. Sutherland, personal communication, 1992). Younger ages of 21 Ma (Smith, 1988) and 23 Ma (Coenraads *et al.*, 1990) were measured on basalts 15 to 20 km to the west of "Mindora", however these are topographically lower and it is unlikely that there are any younger flows in the Mount Buckley sequence.

No volcanoclastic rocks were encountered in the Mount Buckley area.

**Analytical methods.** The basalt samples were sawn

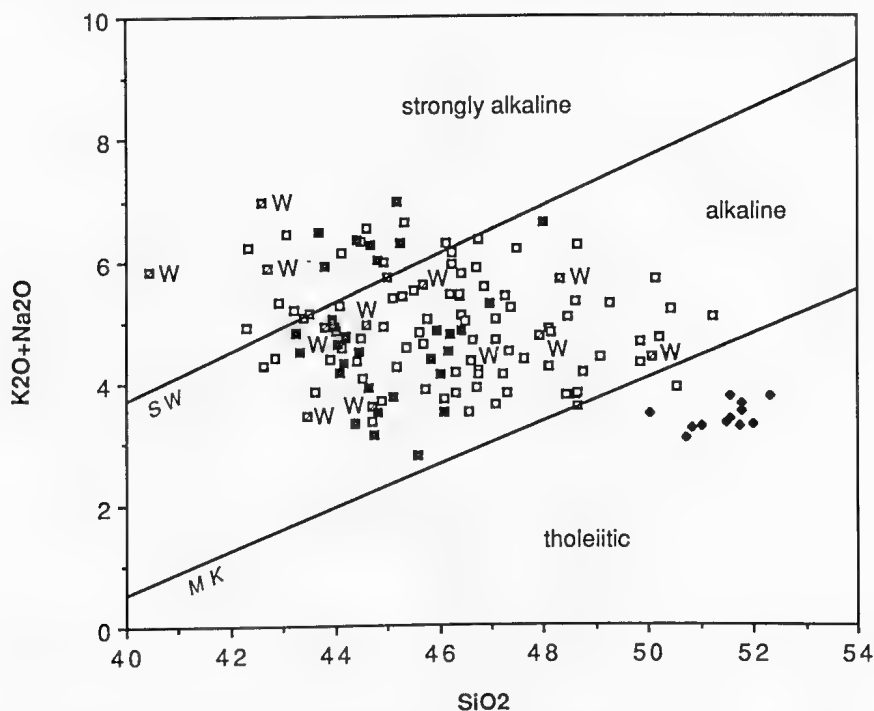
to remove all weathering surfaces, cracks and fractures. Each sample was sawn into slices, from which a representative thin section was made for examination (see Appendix II). The slices were broken and crushed in a tungsten carbide N.V. Tema mill. Sources of contamination, such as xenoliths, megacrysts and vugs were removed prior to crushing.

Major and trace element abundances were obtained by X-ray fluorescence spectrometry. Fused borate buttons were used for the major elements and pressed pellets were used to determine 15 trace elements. All samples were prepared in duplicate. Measurements were made on a Siemens SRS1 sequential X-ray spectrometer with a Siemens Kristallaflex 800 X-ray generator.

FeO analyses were made by hydrofluoric acid digestion and titration with ceric sulphate. The volatiles  $H_2O$ ,  $H_2O^+$  and  $CO_2$  were determined by the fusion and collection method using a Leco induction furnace.

**Treatment of the analytical data.** For meaningful comparisons between rock chemistries (Table 1 [Appendix I]), the raw analytical data were treated as follows.

i) The maximum  $Fe_2O_3/FeO$  ratio was set at 0.2. Original ratios above this value were recalculated to 0.2. Although post eruptive alteration may have caused some oxidation of FeO to  $Fe_2O_3$ , this value is somewhat arbitrary due to the uncertainty of the pre-eruptive  $Fe_2O_3/FeO$  ratio (Wass, 1980).



**Fig.4.** Total alkalis versus silica plot – Central Province, NSW. The lines of MacDonald & Katsura (1964) (MK) and Saggerson & Williams (1964) (SW) divide the plot into sub-alkaline (tholeiitic), alkaline and strongly alkaline fields. All existing analyses of basalts of the Central Volcanic Province are shown as open squares (Wilkinson, 1962; Wilkinson, 1966; Binns, 1969; Binns *et al.*, 1970; Duggan, 1972; Wilkinson, 1973; Wilkinson & Duggan, 1973; Street, 1974; McKay, 1975; McQueen, 1975; Barron, 1987; W.J. Stroud, J.K. Karaolis & R.R. Coenraads, unpubl. data), and the Mount Buckley analyses (this paper) as filled squares. The tholeiites from the Inverell area (Duggan, 1972) are plotted as filled diamonds. Analyses marked with 'w' are alkaline lavas from the sapphire-barren West Central Province.

ii) Volatiles  $H_2O$ ,  $CO_2$  and S are included in the weight percent oxide totals (Table 1 [Appendix I]). Totals have not been rescaled to 100%.

iii) Samples showing post eruptive alteration must be interpreted with caution. Such evidence was seen in the thin section modal mineralogy, or determined from the chemical analyses as high  $H_2O+$  (greater than 4%) or high  $CO_2$  (greater than 0.5%) from secondary minerals such as zeolite or calcite, and/or a high  $Fe_2O_3/FeO$  ratio (greater than 0.75) from oxidation of ferrous iron. Mount Buckley analyses excluded from interpretation are B15 (approximately 20% modal zeolite, 5.02%  $H_2O$ ); B21 (1.84%  $CO_2$ ), B22 (alteration of phenocrystal olivine and along fractures, carbonate veining, 2.82%  $CO_2$ ,  $Fe_2O_3/FeO=0.79$ ); B24 (alteration of phenocrystal olivine, alteration along fractures,  $Fe_2O_3/FeO=1.04$ ); B27 (alteration of phenocrystal olivine, approximately 20% modal zeolite); and B28 (alteration of phenocrystal olivine, presence of zeolite-filled vesicles). They appear to be alkaline, as defined by Wilkinson (1974), based on their modal mineralogy (see Appendix II).

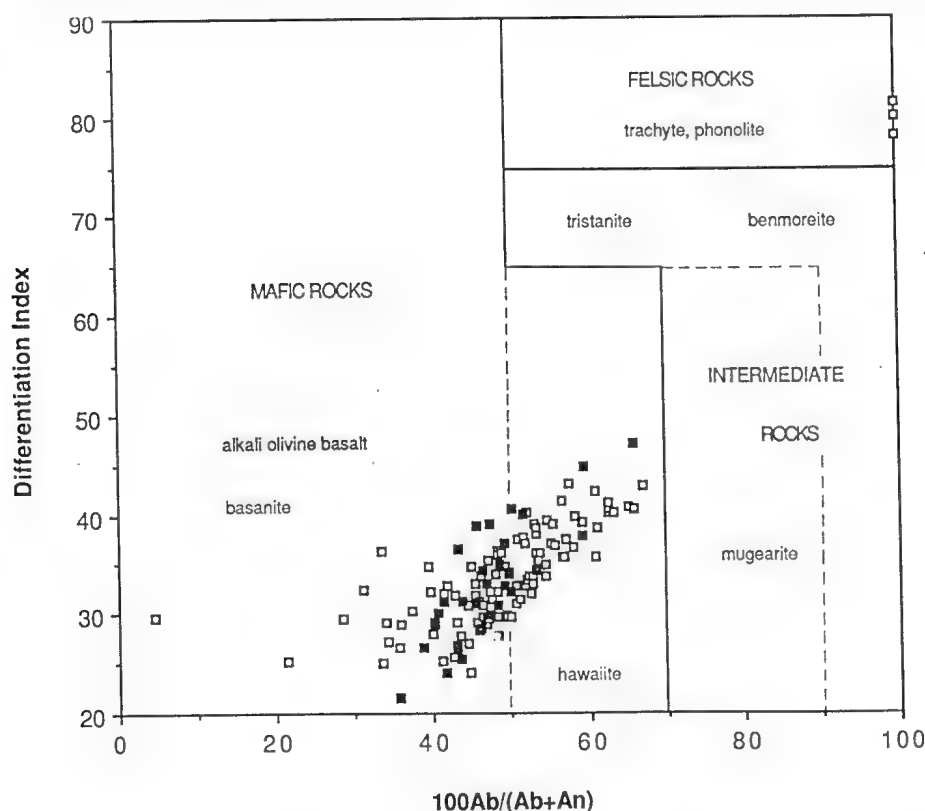
**Nomenclature.** The basalts are named on their chemical composition and normative components following Green & Ringwood (1967) and Coombs & Wilkinson (1969). The criteria used by Johnson (1989: 13) to separate sub-alkaline (tholeiitic) from alkaline rocks requires that sub-alkaline rocks have normative quartz, or more than 10% normative hypersthene. This scheme

however classifies as sub-alkaline a number of earlier Central Province analyses (in which the percentage  $SiO_2$  was calculated by difference and, as a result, is probably too high). These are however clearly alkaline based on their mineralogy (McKay, 1975; McQueen, 1975) according to Wilkinson's (1974) criteria (containing mauve-pink titaniferous augite as the only pyroxene, olivine as a groundmass phase, and various amounts of modal feldspathoid). Analyses are shown on an alkalis ( $Na_2O + K_2O$ ) versus silica plot (Fig.4) with the dividing lines of MacDonald & Katsura (1964) and Saggerson & Williams (1964) provided as a reference. This diagram possesses limitations for those rocks which plot close to the alkalic-tholeiitic dividing line, (Wilkinson 1974).

The alkaline rocks (Fig.5) have been classified using the scheme proposed by Coombs & Wilkinson (1969) based on their normative plagioclase versus differentiation index (D.I. = normative quartz + orthoclase + albite + nepheline + leucite). Rocks with D.I. under 75 and greater than 5% normative nepheline include basanite or are prefixed with "nepheline" as shown in Figure 6.

### Chemical Features of the Mount Buckley Lavas

All the Mount Buckley Series rocks are basic, as  $SiO_2$  lies between 45 and 50% (Carmichael *et al.*, 1974: 29). Plots of normative hypersthene or nepheline against



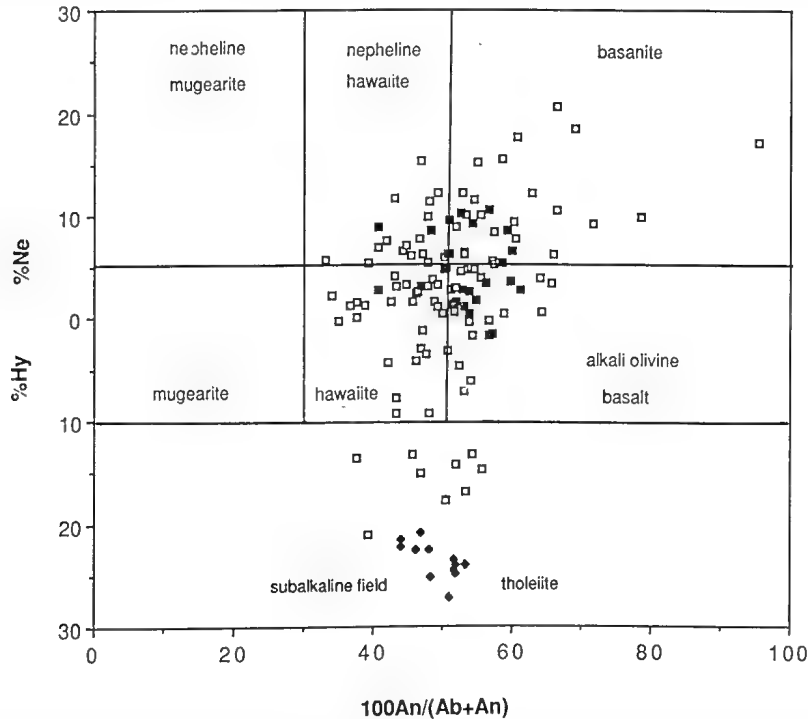
**Fig.5.** C.I.P.W. normative plagioclase versus differentiation index (D.I. = normative quartz + orthoclase + albite + nepheline + leucite) – Central Province, NSW. All existing analyses of basalts of the Central Volcanic Province are shown as open squares (see Fig.4 for sources of database), and the Mount Buckley analyses (this paper) as filled squares. The analyses in the felsic field are phonolites from the Swan Peak Plug (W.J. Stroud, J.K. Karaolis & R.R. Coenraads, unpublished data).



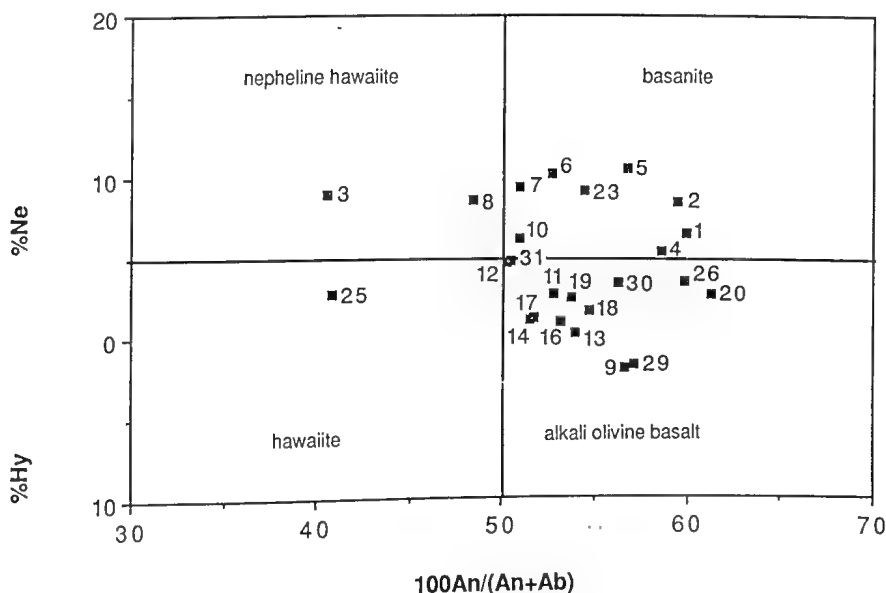
normative plagioclase composition (Fig.7) shows most are alkali olivine basalts and basanites. The uppermost flows are predominantly basanite and nepheline hawaiites whilst the lowermost are predominantly alkali olivine

basalts and hawaiites.

A positive correlation can be seen on the normative plagioclase versus differentiation index plot (Fig.5). However there is no systematic variation between



**Fig.6.** C.I.P.W. nepheline or hypersthene versus normative plagioclase – Central Province, NSW. Lines of Coombs & Wilkinson (1969) subdivide the field of alkaline rocks. Rocks with greater than 5% normative nepheline include basanites, or are prefixed with “nepheline”. All analyses for the Central Province are shown, with the Mount Buckley basalts shown as filled squares, and the tholeiites from the Inverell area as filled diamonds. Note some of the earlier Central Province analyses of basalts described as alkaline, based on their modal analyses, plot in the subalkaline field as %SiO<sub>2</sub> has been calculated by difference and is probably erroneously high (McQueen, 1975).



**Fig.7.** C.I.P.W. nepheline or hypersthene versus normative plagioclase for the Mount Buckley analyses. The uppermost flows (B1 to B10) are largely nepheline hawaiites and basanites and the lower flows (B11 to B31) are largely alkali olivine basalts and hawaiites. Flows B9 and B23 are the only exceptions to this observation.

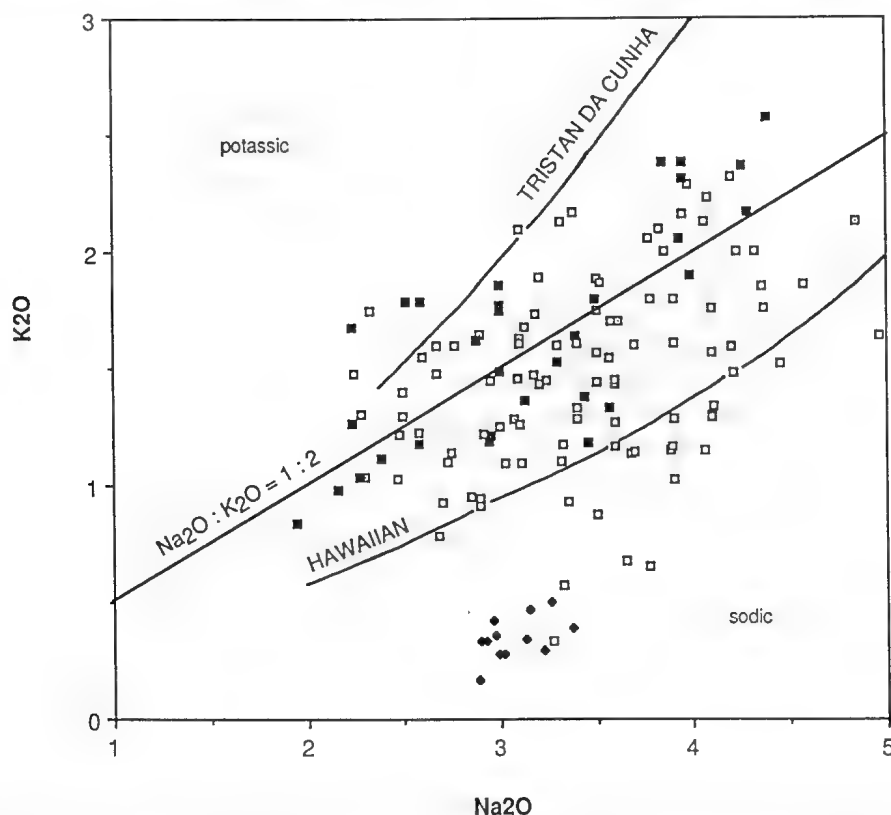


stratigraphic position and position on this plot.

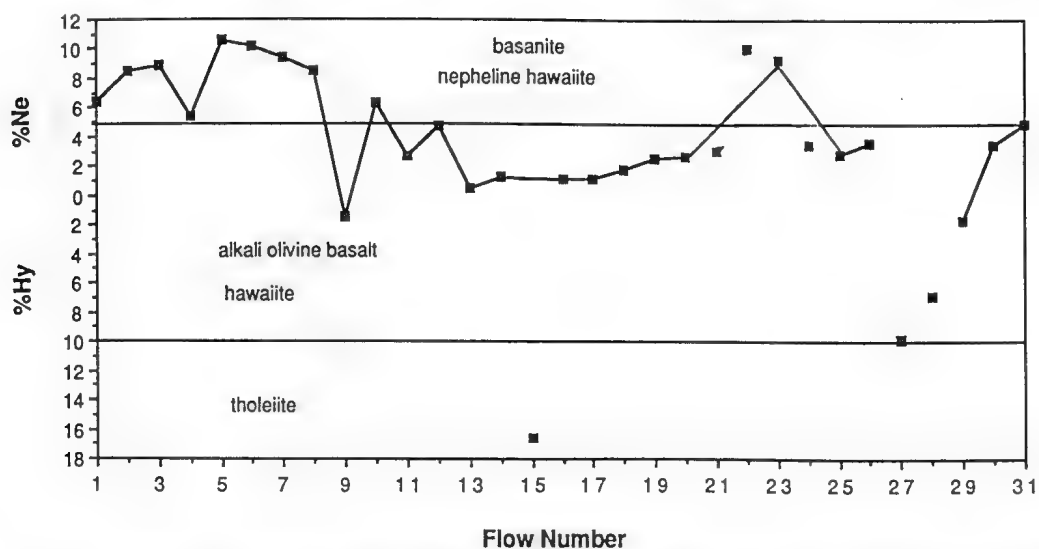
In terms of alkalis ratio,  $K_2O:Na_2O$ , the Mount Buckley flows (Fig.8) tend to cluster about the line  $K_2O:Na_2O = 1:2$  between the sodic Hawaiian alkalic suite (McDonald & Katsura, 1964) and the potassic Tristan de Cunha alkalic series (Baker *et al.*, 1964).

**Chemistry versus stratigraphic position at Mount Buckley.** Normative hypersthene or nepheline (Fig.9), major oxides (Fig.10), and trace elements (Fig.11) were plotted versus flow number to discern any trends.

Increasing silica undersaturation with time appears in Figure 9. The upper flows, B1 to B10 are basanites and



**Fig.8.**  $Na_2O$  versus  $K_2O$  plot – Central Province, NSW. Basalts of the Central Volcanic Province are plotted, with the Mount Buckley analyses shown as filled squares. The field for the Central Province is centred about the line  $Na_2O:K_2O = 2:1$  and lies between the sodic Hawaiian alkalic suite (McDonald & Katsura, 1964) and the potassic Tristan de Cunha series (Baker *et al.*, 1964). The group of analyses low in  $K_2O$  (filled diamonds) are the tholeiites in the vicinity of Inverell mapped by Duggan (1972).

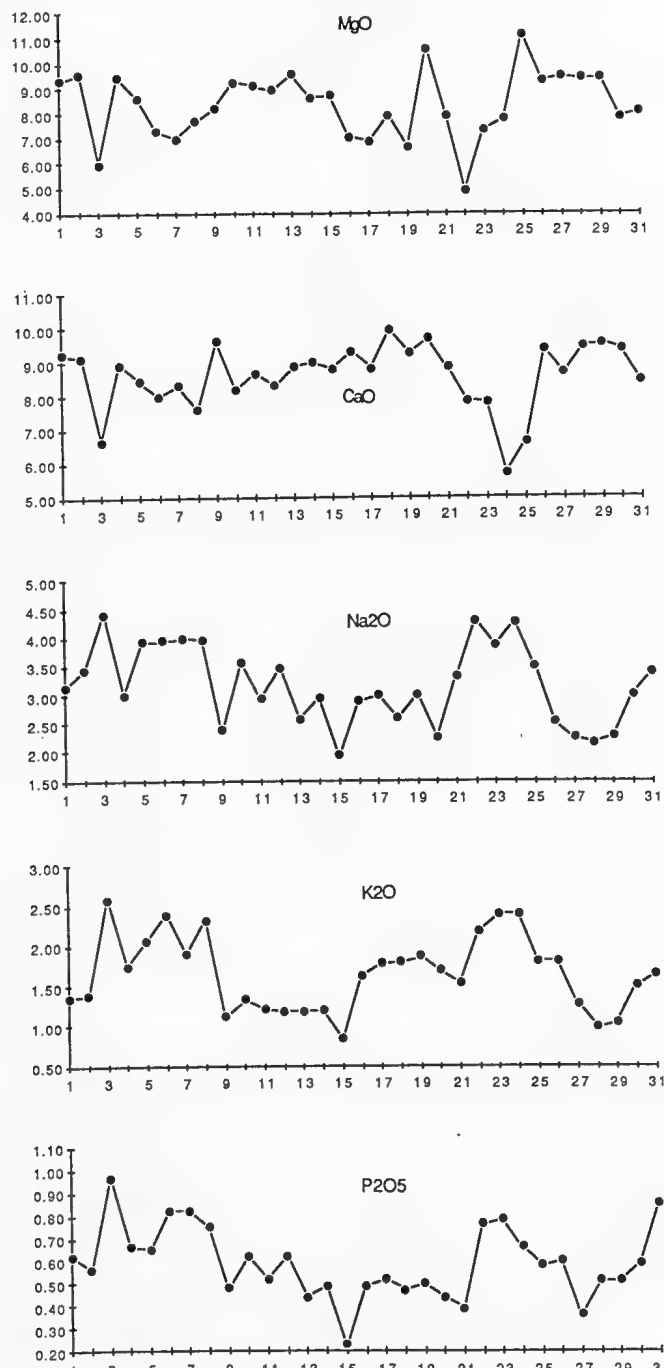
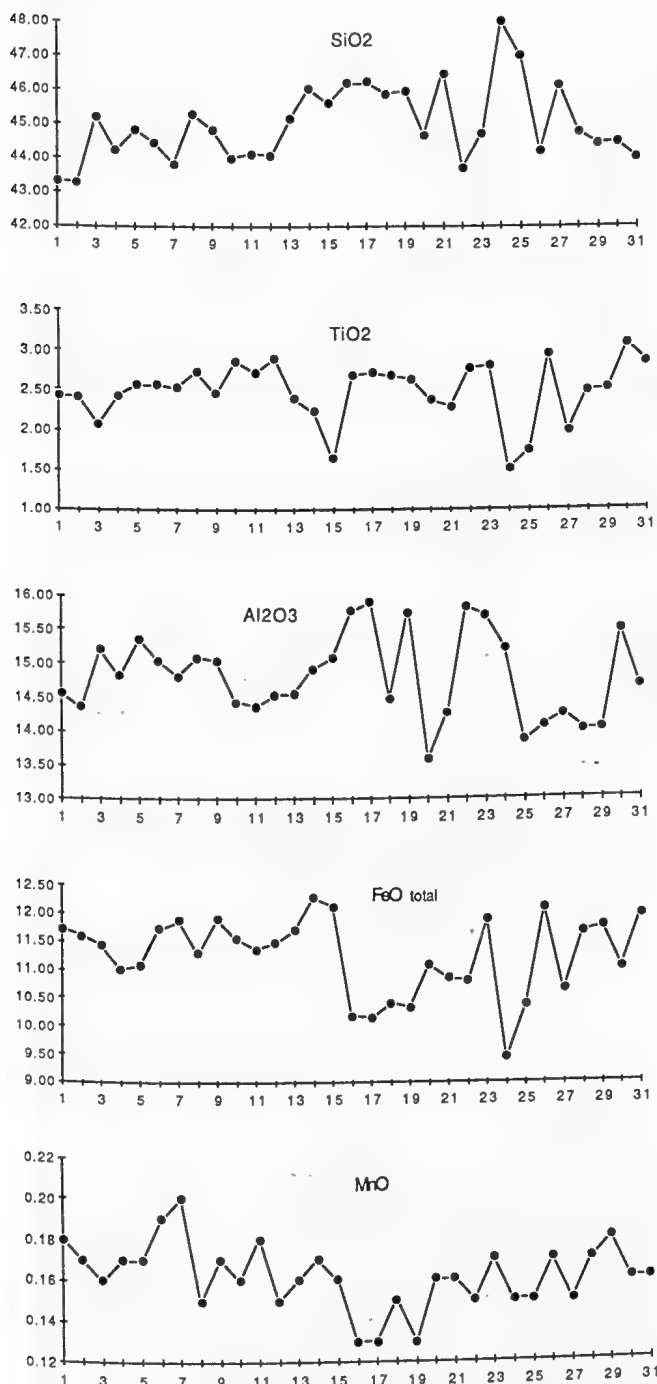


**Fig.9.** C.I.P.W. nepheline or hypersthene versus flow number – Mount Buckley. The numbers are from 1, the youngest flow at the top of Mount Buckley to the lowermost flows. The plot shows that the uppermost flows are, in general, more undersaturated than the lowermost flows. B15, B21, B22, B24, B27 and B28 are not considered suitable for comparison of normative mineralogy and are not linked to adjacent flows by the solid line.

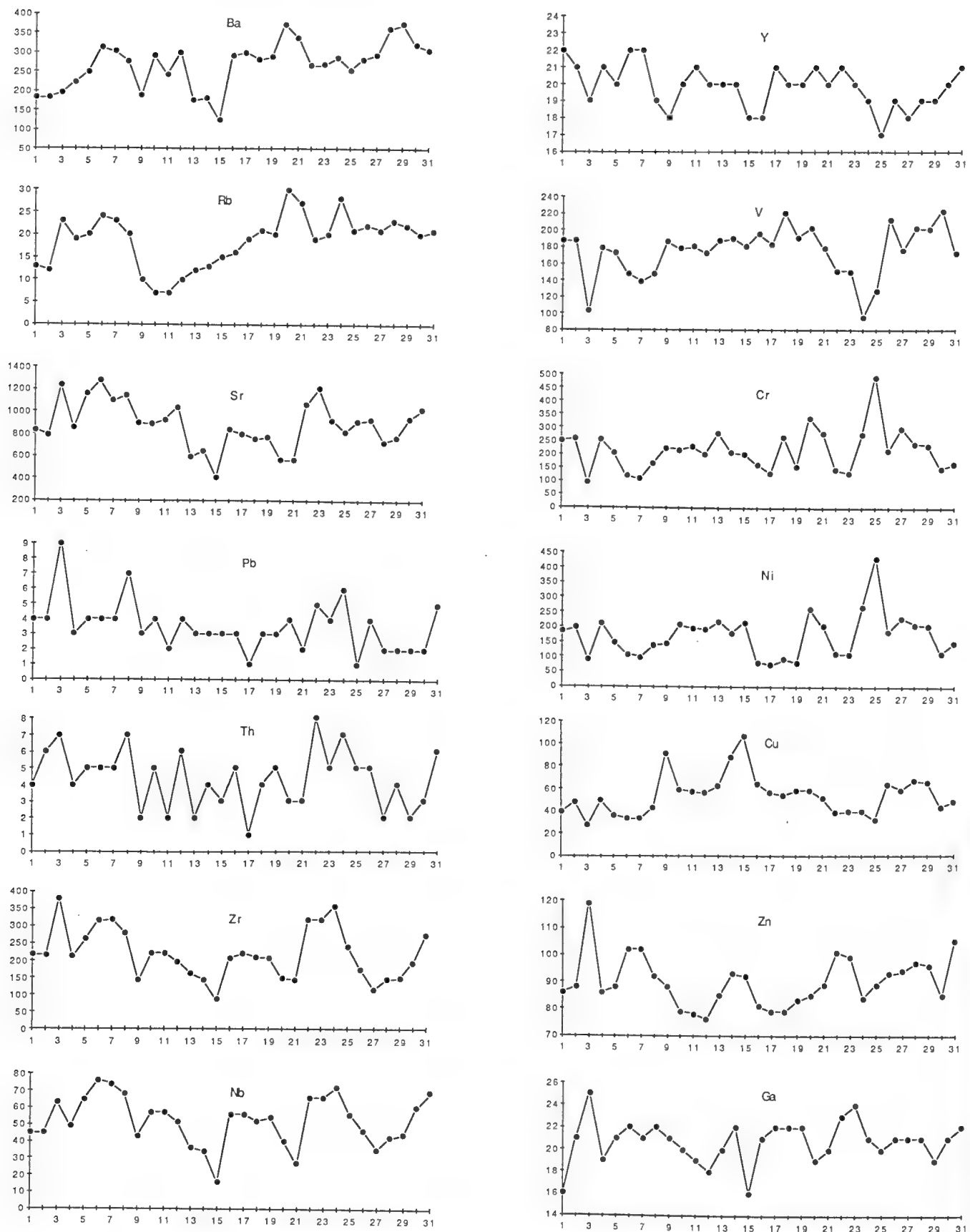
nepheline hawaiites (greater than 5% normative nepheline) with one coarse alkali olivine basalt (B9). B3 is chemically quite distinct having the highest Zn (119 ppm), Zr (377 ppm),  $K_2O$  (2.71%),  $Na_2O$  (4.63%),  $P_2O_5$  (1.01%) and Ga (25 ppm), high Sr (1237 ppm), low Ca (7.02%), Ni (92 ppm), MgO (6.27%) and V (103 ppm) and the lowest Cr (94 ppm) and Cu (27 ppm). B9 also differs from its neighbours with distinct CaO, Zr, Nb and Cu values, but their field relations are conformable. The lower flows B11 to B26 are mildly undersaturated alkali olivine basalts or hawaiites with one basanite (B23). The additional lower flows, B29 to B31 are also alkali olivine

basalts.

Figures 10 and 11 show systematic correlations between the different major and trace elements, such as  $Al_2O_3$ , MgO, CaO,  $Na_2O$ ,  $P_2O_5$ , V, Cr and Ni. Some adjacent units within the Mount Buckley sequence behave as groups, the members of each group being chemically and petrographically consistent. Flows B16, B17, B18 and B19 are coarse grained alkali olivine basalts; flows B10, B11, B12 and B13, are a fine grained basanite and alkali olivine basalts; and flows B5, B6, B7 and B8 are basanites and a nepheline hawaiite. Some elements in these groups change in a regular way from unit to unit



**Fig.10.** Major elements versus flow number. The plots allow comparisons to be made between successive flows. Number 1 is the youngest, uppermost flow on Mount Buckley. Major elements are plotted as oxide weight percents.



**Fig.11.** Trace elements versus flow number. The plots allow comparisons to be made between successive flows. Number 1 is the youngest, uppermost flow on Mount Buckley. Trace elements are plotted as parts per million.

indicating a possible fractionation pattern.

Overall, the Mount Buckley sequence (Figs 10, 11), ignoring chemically distinct B3, shows  $\text{SiO}_2$  increasing reasonably smoothly from 45% in B1 to 48% in B19. V decreases from B1 to a minimum in B7 then increases again from B8 to B18. CaO follows a similar trend with a minimum at B8. MgO also shows a minimum in B7.

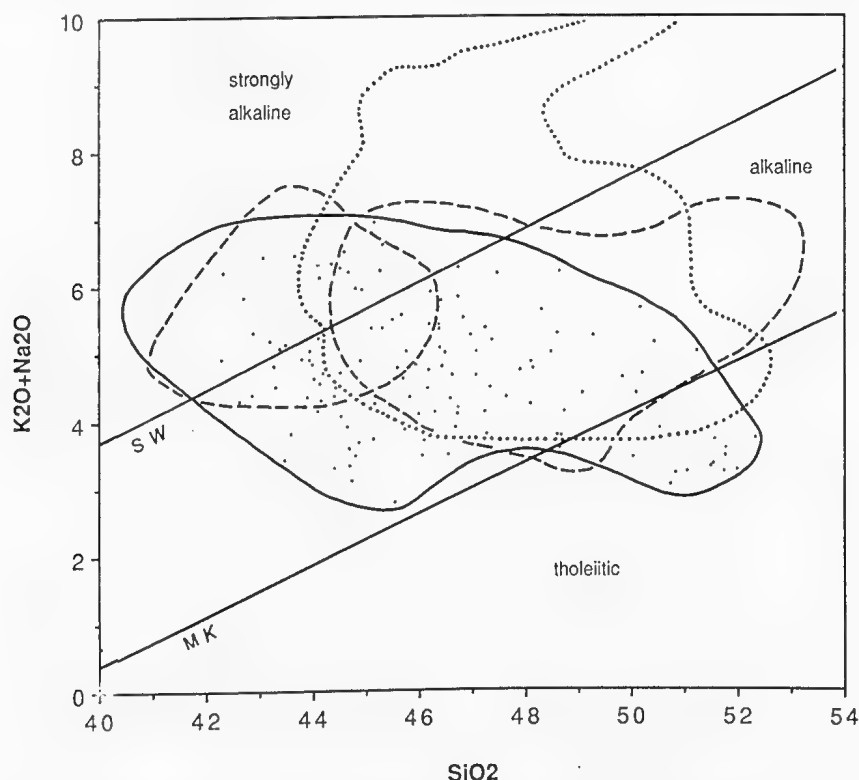
**Xenolith-bearing and primary lavas at Mount Buckley.** Ultramafic xenoliths occur in B1, B2, B4, B6, B7, B10, B12, B24 and B25. The pyroxenite and lherzolite bearing flows, described by Wilkinson (1973), are in a small tributary of Youngs' Creek (GR:520075 Inverell 1:100,000, Fig.3; L. Stewart, personal communication). The tributary incises Vol Aston Hill, comprised of flows B24 and B25. Wilkinson (1973) interpreted the pyroxenites and peridotites to be samples of essentially unmodified, layered upper mantle. Such xenoliths are characteristic of more alkaline and undersaturated melts which move directly and rapidly from upper mantle levels to the surface. These xenolith-bearing melts are either primary or are produced by high pressure crystal fractionation (Irving & Green, 1976; Wass, 1980). Primary alkaline magmas show Mg-values ( $100\text{Mg}/\{\text{Mg}+\text{Fe}^{2+}\}$ ) of 66 to 75, which represent liquids that could be in equilibrium with upper mantle residual olivine compositions (Fo89 - Fo99) and high Ni values (greater than 300 ppm)

B25 (Mg-value = 69, Ni = 429 ppm) satisfies these criteria and shows the highest MgO, Cr and Ni in the sequence. The rest of the xenolith-bearing flows have Mg values below 65 and Ni less than 300 ppm, suggesting high pressure fractionation in the mantle (Green *et al.*, 1974) or direct derivation from more iron rich peridotite (Wilkinson & Binns, 1977). Such conditions of rapid transport to the surface also help the preservation of sapphires in carrier magmas (Coenraads *et al.*, 1990)

The coarse grained flows (B9, B11, B14, B15, B16, B17, B18, and B19) lack xenoliths, a feature noted by Wass (1980) for flows in the Southern Highlands. This may indicate either a longer transit time to the surface or temporary residence in a magma chamber for such flows. This would reduce their role as sapphire carriers.

### Comparison between the Sapphire-bearing East and Sapphire-barren West Central Province

The Central Province analyses were separated into those from the sapphire-bearing East and sapphire-barren West Central Province. Analyses near the dividing boundary (the MacIntyre River) were included with the East as these incorporate the majority and are likely to include both sapphire-bearing and sapphire-barren flows. This grouping was to test whether the sapphire-barren flows form a separate subset or a distinct smaller



**Fig.12.** Total alkalis versus silica plot – Central Province, NSW. Dot points indicate the compositional database for the Central Province basalts. The compositional field of the Central Volcanic Province, outlined by a solid line, and that of the north-eastern Australian corundum-bearing provinces (Atherton, Chudleigh and McBride; Stephenson *et al.*, 1980), outlined by a dotted line, are superimposed on the overlapping fields for the corundum-bearing (dashed line, left hand field) and corundum-less (dashed line, right hand field) south-east Asian volcanic provinces (Vichit *et al.*, 1978).

compositional field, as was observed by Vichit *et al.* (1978) for the south-east Asian volcanic provinces. However, apart from more tholeiitic compositions, the remaining sapphire-barren West Central Province analyses range over the entire compositional field, (see samples flagged with 'w' in Fig.4). The tholeiites found by Duggan (1972) are distinct from any basalts in the East Central Province. Such tholeiites may be an indicator against finding sapphire as they show evidence of some low pressure fractional crystallisation (Wilkinson & Duggan, 1973), suggesting residence at shallower levels.

### Comparison between the Central Province and other Volcanic Provinces in North-eastern Australia and South-east Asia

Stephenson *et al.* (1980) compare the compositional fields for the north Queensland volcanic provinces on a number of variation diagrams (alkalis versus silica,  $K_2O$  versus  $Na_2O$ , AFM, and normative plagioclase versus differentiation index plots). The compositional fields largely overlap one another, and those known to have associated sapphire (Atherton, Chudleigh and McBride) are not significantly different from the rest of the north Queensland provinces. Not surprisingly, the Central Province compositional field also overlaps these plots (Fig.12). The implications are that, either all the north Queensland provinces and the West Central Province are potentially sapphire-bearing, or more likely, that this type of data and its scatter are insufficient to predict likely sapphire-bearing and sapphire-barren provinces.

### Conclusions

1. The East Central Province was broken up into catchments and those containing the most alluvial sapphire were selected as the most likely places to characterise sapphire source rocks.

2. The Mount Buckley basalts increase in undersaturation with time, from predominantly alkali olivine basalts and hawaiites to predominantly basanites and nepheline hawaiites. They probably represent intercalated flows from several different mantle and crustal sources, particularly as many of the major and trace element values for flows, such as B3 and B9, vary markedly from their neighbouring flows. Flow B25 is a possible primary representative. A large number of the flows carry high pressure inclusions, implying their rapid movement from upper mantle depths.

3. There is little distinction between the compositions from the sapphire-bearing East Central Province and the sapphire-barren West Central province on the variation diagrams, apart from the tholeiites west of Inverell.

4. The compositional fields for the north-eastern Australian volcanic provinces and the Central Province

overlap with no apparent compositional variation between those fields known to contain corundum and the remainder.

5. The compositional field for the Central Province overlaps both the corundum-bearing and corundum-less fields for the south-east Asian volcanic provinces.

6. Chemical variations in basaltic fields do not appear sensitive indicators to predict economic sapphire deposits.

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## APPENDIX I

Table 1. Mount Buckley basalt analyses and C.I.P.W norms.

Sample Number	B1	B2	B3	B4	B5	B6	B7	B8	B9	B10	B11	B12	B13	B14	B15
Location	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley	Mt Buckley
1:25000 Map Sheet	Elsmore	Elsmore	Elsmore	Elsmore	Elsmore	Elsmore	Sapphire	Sapphire	Sapphire	Sapphire	Sapphire	Sapphire	Sapphire	Sapphire	Sapphire
Grid Reference	54800756	54730765	54630769	54600774	54520775	54380775	54130825	54040827	53950834	53890829	53560854	53530860	53470867	53090936	52890972
Elevation (metres)	1168	1160	1142	1135	1129	1115	1100	1078	1065	1056	1050	1045	1043	1035	1015
Oxide wt%															
SiO <sub>2</sub>	43.31	43.26	45.18	44.20	44.81	44.41	43.80	45.25	44.81	43.96	44.10	44.04	45.12	46.00	45.57
TiO <sub>2</sub>	2.42	2.41	2.08	2.43	2.57	2.57	2.53	2.73	2.46	2.86	2.71	2.89	2.39	2.23	1.64
Al <sub>2</sub> O <sub>3</sub>	14.55	14.36	15.20	14.82	15.35	15.03	14.81	15.08	15.03	14.43	14.36	14.54	14.56	14.92	15.07
FeO	4.12	3.71	5.05	3.18	3.09	4.30	3.81	3.90	3.29	4.10	4.20	4.78	3.92	2.14	2.18
MnO	8.00	8.25	6.88	8.15	8.29	7.86	8.45	7.79	8.95	7.86	7.58	7.17	8.17	10.35	10.15
MgO	0.18	0.17	0.16	0.17	0.19	0.19	0.20	0.15	0.17	0.16	0.18	0.15	0.16	0.17	0.16
CaO	9.32	9.56	5.94	9.44	8.60	7.29	6.97	7.67	8.20	9.22	9.10	8.91	9.55	8.62	8.70
Na <sub>2</sub> O	9.22	9.12	6.55	8.02	8.43	8.00	8.30	7.62	8.60	8.19	8.67	8.30	8.87	8.98	8.79
K <sub>2</sub> O	3.13	3.44	4.39	3.00	3.93	3.95	3.99	3.95	2.39	3.57	2.95	3.46	2.58	2.94	1.95
P <sub>2</sub> O <sub>5</sub>	1.36	1.38	2.57	1.75	2.06	2.38	1.90	2.31	1.12	1.33	1.21	1.18	1.18	1.19	0.84
S	0.62	0.56	0.96	0.66	0.65	0.82	0.82	0.75	0.48	0.62	0.52	0.62	0.44	0.23	0.49
H <sub>2</sub> O+	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.01	0.00	0.00	0.01	0.01	0.01	0.03
H <sub>2</sub> O-	2.77	2.58	3.35	2.42	1.86	2.10	3.48	1.48	2.51	2.17	2.99	2.37	2.14	0.93	4.29
CO <sub>2</sub>	0.77	0.74	0.91	0.59	0.47	0.57	0.52	0.46	0.53	0.56	0.67	0.55	0.73	0.40	0.40
CO <sub>2</sub>	0.17	0.22	0.10	0.19	0.11	0.12	0.13	0.08	0.10	0.08	0.07	0.06	0.03	0.06	0.09
Original Total	99.94	99.76	99.42	99.92	100.39	99.59	99.71	99.22	99.65	99.11	99.31	99.15	99.67	99.43	100.42
Total Fe as FeO	11.71	11.59	11.42	11.01	11.07	11.73	11.88	11.30	11.91	11.55	11.36	11.47	11.70	12.28	12.11
original Fe <sub>2</sub> O <sub>3</sub> /FeO	0.52	0.45	0.73	0.39	0.37	0.55	0.45	0.50	0.37	0.52	0.55	0.67	0.48	0.21	0.21
required Fe <sub>2</sub> O <sub>3</sub> /FeO	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
New Fe <sub>2</sub> O <sub>3</sub>	1.98	1.96	1.94	1.87	1.88	1.99	2.01	1.92	2.02	1.96	1.93	1.94	1.98	2.08	2.05
New FeO	9.92	9.82	9.68	9.33	9.38	9.84	10.07	9.58	10.09	9.79	9.63	9.72	9.91	10.40	10.26
New Total	99.73	99.59	99.11	99.79	100.27	99.36	99.53	99.02	99.52	98.90	99.08	98.87	99.48	99.42	100.41
Orthoclase	8.06	8.15	15.17	10.32	12.16	14.08	11.24	13.63	6.63	7.88	7.17	6.95	6.99	7.02	4.97
Albite	14.49	13.46	20.72	15.44	13.84	14.60	16.30	17.65	20.22	18.68	19.94	20.52	21.03	22.44	16.53
Nepheline	8.50	8.48	8.91	5.38	10.53	10.18	8.55	6.25	0.00	2.74	4.73	4.73	0.44	1.33	0.00
Anorthite	21.63	19.67	14.18	21.82	18.15	16.25	16.90	16.57	26.96	19.40	22.34	20.67	24.63	23.99	29.84
Dioptase	15.44	16.61	9.77	13.68	15.17	14.15	14.84	12.89	13.78	13.53	13.64	12.99	13.21	13.88	9.52
Hypersthene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	1.51	0.00	0.00	0.00	0.00	0.00	16.64
Olivine	20.80	20.69	16.89	20.85	18.73	17.50	16.91	17.91	18.44	20.55	20.30	20.06	21.97	20.90	11.02
Magnetite	2.87	2.81	2.81	2.71	2.73	2.89	2.91	2.78	2.93	2.84	2.80	2.81	2.87	3.02	2.97
Ilmenite	4.60	4.57	3.95	4.62	4.89	4.88	4.80	5.19	4.83	5.43	5.14	4.47	4.55	4.24	3.12
Apatite	1.46	1.33	2.28	1.57	1.54	1.94	1.93	1.77	1.13	1.46	1.24	1.47	1.05	1.15	0.55
Calcite	0.39	0.50	0.23	0.43	0.25	0.27	0.30	0.18	0.23	0.18	0.16	0.14	0.07	0.14	0.20
Water	3.54	3.32	4.26	3.01	2.33	2.67	4.00	1.94	3.04	2.73	3.66	3.04	2.69	1.33	5.02
Total	99.78	99.62	99.17	99.83	100.32	99.41	99.57	99.06	99.54	98.93	99.13	98.86	99.50	99.44	100.38
100An/An+Ab	50.9	59.4	40.6	58.6	56.7	52.7	50.9	48.4	57.1	50.9	52.8	50.2	53.9	51.7	64.4
Differentiation Index	29.05	30.09	44.8	31.14	36.53	38.86	36.98	39.83	26.85	32.81	29.85	32.2	28.46	30.79	21.5
Rock Name	basanite	basanite	ne-hawallite	basanite	basanite	basanite	basanite	ne-hawallite	AOB	basanite	AOB	AOB	AOB	AOB	AOB
Trace Elements (ppm)															
Ba	183	184	196	223	250	312	302	276	189	290	243	298	176	181	126
Rb	13	12	23	19	20	24	23	20	10	7	7	10	12	13	15
Sr	832	786	1236	856	1160	1279	1100	1145	896	885	924	1035	592	645	403
Pb	4	4	9	3	4	4	4	7	3	4	2	4	3	3	3
Th	4	6	7	4	5	5	5	7	2	5	2	6	2	4	3
U	1	0	2	2	1	2	2	0	2	2	1	1	1	2	1
Zr	217	215	377	212	261	314	318	279	143	221	222	196	162	143	87
Nb	45	45	63	49	65	76	74	68	34	57	57	36	36	34	16
Y	22	21	19	21	20	22	22	19	18	20	21	20	20	20	18
V	187	187	103	178	172	148	138	148	186	178	180	172	187	190	180
Cr	251	257	94	253	203	117	106	166	223	216	228	202	277	207	202
Ni	185	197	91	210	148	106	97	138	144	206	195	191	217	180	215
Cu	39	48	27	33	36	33	33	43	91	56	57	56	62	88	106
Zn	86	88	119	85	88	102	102	92	88	76	78	76	85	93	92
Ga	16	21	25	19	21	22	21	22	21	20	19	18	20	22	16
K/Rb	868	955	928	765	855	823	686	959	930	1577	1435	980	816	760	465

Table 1 (cont'd).

Sample Number	B16	B17	B18	B19	B20	B21	B22	B23	B24	B25	B26	B27	B28	B29	B30	B31
Location	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire	Mt Buckley Sapphire
1:25000 Map Sheet	51890986	51890862	52020856	52090845	52300830	52200823	52270816	52260786	52470737	52450711	51200625	51980612	52330673	52350660	52440649	52400642
Grid reference	1005	1015	990	960	955	948	940	940	911	892	884	855	903	892	875	865
Elevation (metres)																
Oxide wt%																
SiO <sub>2</sub>	46.16	46.20	45.85	45.94	44.63	46.43	43.67	44.65	47.98	46.95	44.15	46.08	44.73	44.39	44.44	43.95
TiO <sub>2</sub>	2.68	2.71	2.67	2.80	2.37	2.29	2.77	2.80	1.51	1.74	2.95	1.99	2.49	2.51	3.07	2.84
Al <sub>2</sub> O <sub>3</sub>	15.76	15.90	14.47	15.73	13.58	14.26	15.82	15.68	15.21	13.86	14.08	14.24	14.01	14.03	15.48	14.85
Fe <sub>2</sub> O <sub>3</sub>	2.97	3.45	3.64	3.28	3.05	3.29	3.83	3.83	3.62	3.44	3.68	3.68	3.60	3.31	3.84	3.95
MnO	7.51	7.04	7.13	7.38	8.33	7.88	6.32	8.44	4.89	7.27	8.84	7.35	8.43	8.77	7.58	8.40
MgO	0.13	0.13	0.15	0.13	0.16	0.16	0.15	0.17	0.15	0.15	0.17	0.15	0.17	0.18	0.16	0.16
NiO	7.03	6.83	7.88	6.60	10.53	7.87	4.86	7.31	7.72	11.07	9.29	9.44	9.36	9.38	7.82	8.03
CaO	9.28	8.79	9.89	9.23	9.65	8.81	7.82	7.75	5.69	6.59	9.34	8.64	9.32	9.50	8.42	8.42
Na <sub>2</sub> O	2.88	3.00	2.59	3.00	2.24	3.30	4.28	3.85	4.26	3.49	2.52	2.24	2.16	2.27	3.00	3.39
K <sub>2</sub> O	1.62	1.77	1.79	1.86	1.68	1.53	2.17	2.38	2.37	1.80	1.79	1.27	0.98	1.04	1.49	1.64
P <sub>2</sub> O <sub>5</sub>	0.49	0.52	0.47	0.50	0.44	0.39	0.76	0.78	0.66	0.58	0.60	0.36	0.51	0.51	0.59	0.85
S	0.02	0.01	0.00	0.01	0.01	0.00	0.01	0.01	0.00	0.00	0.01	0.00	0.01	0.01	0.00	0.00
H <sub>2</sub> O <sup>+</sup>	2.40	2.76	2.35	2.59	2.49	1.08	2.43	1.66	2.65	2.07	1.71	3.35	3.24	3.25	2.35	2.25
H <sub>2</sub> O <sup>-</sup>	0.59	0.61	0.49	0.50	0.38	0.41	1.00	0.45	0.45	0.05	0.47	0.57	0.72	0.53	0.74	1.02
CO <sub>2</sub>	0.01	0.06	0.09	0.08	0.03	1.84	2.82	0.05	0.29	0.02	0.08	0.04	0.09	0.03	0.21	0.29
Original Total	99.53	99.78	99.46	99.45	99.57	99.54	99.86	99.81	98.90	99.37	99.62	99.40	99.92	99.33	100.09	99.84
Total Fe as FeO	10.18	10.14	10.41	10.33	11.07	10.84	10.80	11.89	9.45	10.37	12.10	10.66	11.67	11.75	11.04	11.95
original Fe <sub>2</sub> O <sub>3</sub> /FeO	0.40	0.40	0.51	0.44	0.37	0.42	0.79	0.45	1.04	0.47	0.41	0.50	0.43	0.38	0.51	0.47
required Fe <sub>2</sub> O <sub>3</sub> /FeO	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20	0.20
New Fe <sub>2</sub> O <sub>3</sub>	1.73	1.72	1.76	1.75	1.88	1.84	1.83	2.01	1.83	1.76	2.05	1.99	1.98	1.99	1.87	2.03
New FeO	8.63	8.60	8.82	8.76	9.39	9.19	9.15	10.07	8.01	8.78	10.25	9.04	9.89	9.96	9.35	10.13
New Total	99.41	99.61	99.27	99.30	99.45	99.39	99.54	99.63	98.55	99.20	99.46	99.21	99.76	99.20	99.89	99.65
Orthoclase	9.57	10.47	10.57	11.00	9.94	9.04	12.82	14.06	13.98	10.66	10.56	7.50	5.80	6.14	8.80	9.66
Albite	22.33	23.24	18.66	20.68	13.90	22.21	17.68	15.50	29.62	24.39	14.70	18.94	18.28	19.20	18.98	19.65
Nepheline	1.10	1.16	1.77	2.54	2.74	3.09	3.09	9.23	3.46	2.76	3.57	0.00	0.00	0.00	3.46	4.89
Anorthite	25.27	24.67	22.55	23.95	22.04	19.57	17.54	18.48	15.40	16.84	21.84	25.04	25.63	25.02	24.37	19.94
Diopside	14.22	12.33	18.55	14.76	18.39	17.57	13.43	11.90	5.42	9.59	16.25	12.26	13.97	15.08	13.57	11.77
Hypersthene	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
Olivine	15.14	15.38	15.42	14.41	21.28	16.67	12.10	18.18	20.19	25.30	20.19	14.36	16.25	19.68	17.24	19.50
Magnetite	2.51	2.49	2.55	2.54	2.73	2.67	2.85	2.91	2.32	2.55	2.97	2.62	2.87	2.89	2.71	2.94
Ilmenite	5.09	5.15	5.07	4.98	4.49	4.35	5.26	5.31	2.86	3.30	5.60	3.78	4.73	4.77	5.83	5.40
Apatite	1.16	1.24	1.11	1.17	1.05	0.92	1.80	1.85	0.66	1.38	1.43	0.86	1.21	1.21	1.39	2.01
Calcite	0.02	0.14	0.20	0.18	0.07	0.00	0.00	0.11	0.56	0.05	0.18	0.11	0.20	0.07	0.48	0.66
Water	2.99	3.37	2.84	3.09	2.87	1.48	3.43	2.11	3.10	2.41	2.18	3.92	3.96	3.40	3.09	3.27
Total	99.40	99.64	99.29	99.30	99.50	97.58	96.75	99.64	98.57	99.23	99.47	99.24	99.78	99.22	99.92	99.69
100An/An+Ab	53.1	51.5	54.7	53.7	61.3	46.8	49.8	54.4	34.2	40.8	59.8	56.9	58.4	56.6	56.2	50.4
Differentiation Index	33	34.87	31	34.22	26.58	34.34	40.54	38.79	47.06	37.81	28.83	26.44	24.08	25.34	31.24	34.2
Rock Name	AOB	AOB	AOB	AOB	AOB	hawaiite	hawaiite	basanite	hawaiite	hawaiite	AOB	AOB	AOB	AOB	AOB	AOB
Trace Elements (ppm)																
Ba	291	298	280	288	372	337	266	268	286	255	282	293	361	373	319	305
Rb	16	19	21	20	30	27	19	20	28	21	22	21	23	22	20	21
Sr	838	800	753	773	564	565	1066	1211	924	817	914	931	730	772	937	1022
Pb	3	1	3	3	4	2	5	4	6	1	4	2	2	2	2	5
Th	5	1	4	5	3	3	8	5	7	5	5	2	2	2	3	6
U	2	1	1	1	2	3	3	3	3	2	2	2	0	2	1	2
Zr	208	221	209	208	148	143	318	317	357	241	173	117	146	149	194	272
Nb	56	56	52	54	40	27	66	66	72	56	46	35	42	44	60	69
Y	18	21	20	21	20	20	19	20	18	17	19	19	19	19	20	21
V	183	195	220	191	202	178	151	150	127	127	212	176	202	201	223	172
Cr	162	129	263	153	337	280	143	130	276	489	216	297	240	234	147	163
Ni	81	73	92	80	261	203	111	110	268	429	186	230	208	204	113	146
Cu	64	56	54	58	58	51	38	39	39	32	63	58	66	65	48	48
Zn	81	83	79	83	85	89	101	99	84	89	93	93	97	96	85	105
Ga	21	22	22	22	19	20	23	21	21	20	21	21	21	19	21	22
K/Rb	841	773	708	772	465	470	948	988	703	712	675	502	354	392	618	648

## APPENDIX II

Brief Petrographic Descriptions of Mount Buckley Basalts  
(Australian Museum specimen nos DR13549 to DR13579)**B1, B2 basanite**

Very fine grained holocrystalline rock, porphyritic, showing evidence of flow banding. Subhedral to anhedral equant olivine gives the rock a porphyritic texture within a groundmass of euhedral plagioclase laths, stubby euhedral augite prisms, opaque minerals and interstitial nepheline. Some minor alteration is evident in B2.

**B3 nepheline hawaiite**

A very fine grained rock with euhedral altered olivine and ragged anhedral nepheline crystals in a groundmass of euhedral plagioclase laths, opaque minerals and glass. A small patch of anhedral zeolite was noted.

**B4, B5 basanite**

Medium to fine euhedral to subhedral olivine phenocrysts in groundmass of euhedral to subhedral elongate plagioclase laths, equant euhedral to subhedral opaques and augite. Minor alteration of the olivine. Some interstitial glass is evident in B5.

**B6 basanite**

A very fine grained hypohaline rock with a porphyritic texture similar to B3. Subhedral to euhedral olivine, ragged low relief inclusions consisting of equigranular anhedral grains in a groundmass of smaller plagioclase laths and brown glass.

**B7 basanite**

Euhedral olivine phenocrysts or megacrysts in a fine groundmass of short euhedral plagioclase laths and brown glass.

**B8 nepheline hawaiite**

Similar to B6.

**B9 alkali olivine basalt**

A medium-grained holocrystalline rock. Glomoporphyritic texture with medium-sized, zoned, single euhedral crystals or clots of subhedral crystals of pink augite and medium euhedral plagioclase laths. Groundmass comprises of equant subhedral to euhedral finer plagioclase, olivine, pyroxene and opaques with minor brown glass.

**B10 basanite**

Spectacular phenocrysts or megacrysts of equigranular euhedral olivine in a fine groundmass of short euhedral plagioclase laths. Similar appearance to B7 except groundmass is mostly granular with only minimal glass.

**B11 alkali olivine basalt**

Euhedral equant and elongate olivine (with some minor alteration along cracks and around the rims), euhedral elongate

plagioclase and some pink augite aggregates in a fine holocrystalline groundmass of plagioclase laths and euhedral augite and opaques.

**B12 alkali olivine basalt**

Subhedral equant olivine in a fine holocrystalline groundmass of euhedral subparallel plagioclase laths which give the rock a fluidal texture, euhedral equant augite and opaques.

**B13 alkali olivine basalt**

Medium to fine subhedral equant to elongate olivine phenocrysts in a holocrystalline groundmass of finer subhedral to anhedral olivine, plagioclastic laths, very fine equant euhedral augite prisms and opaques.

**B14 alkali olivine basalt**

Medium sized subhedral to euhedral equant to elongate phenocrysts of olivine and zoned pink augites with plagioclase displaying subophitic texture in a fine to medium grained groundmass of elongate euhedral plagioclase equant subhedral olivine, augite and opaques. Rock is essentially equigranular holocrystalline with less than 2% interstitial alteration products. K/Ar dating of this sample yielded an age of  $39.0 \pm 0.3$  Ma. (average of duplicate analyses  $39.1 \pm 0.3$  Ma and  $38.8 \pm 0.3$  Ma, F.L. Sutherland, personal communication, 1992)

**B15 alkali olivine basalt**

A fine to medium grained rock comprising subhedral to euhedral olivine, pink augites displaying a subophitic relationship with the included plagioclase, and equant euhedral opaque minerals. The rock is essentially holocrystalline with interstitial areas filled with a equant anhedral low relief, low birefringence zeolite. Sample is unsuitable for chemical comparison.

**B16, B17, B18, B19 alkali olivine basalt**

Medium to coarse grained glomoporphyritic aggregates of subhedral pink augite and medium to coarse grained elongate subhedral to euhedral plagioclase which are crudely aligned imparting a trachytic texture to the rock. Some altered clots of euhedral crystals probably were olivine phenocrysts or megacrysts. The groundmass consists of fine euhedral augite and isotopic brown glass with some euhedral, equant and acicular opaque minerals. Zoning of augite from light centres to pink rims indicates titanium enrichment. B17 contains some ragged edged euhedral feldspars with a curved, less distinct zoning. B18 and B19 include more aggregates of ophitic pink augite.

**B20 alkali olivine basalt**

Fine to medium grainsize, euhedral single augite (zoned with a darker pink rim) and olivine crystals in a finer granular groundmass comprising euhedral augite, subhedral opaques and feldspar laths with some minor anhedral granular aggregates of alkali feldspars.

**B21 hawaiiite**

Equant to elongate subhedral olivine megacrysts in a holocrystalline fine to medium grain size groundmass of plagioclase, pink augite and opaques.

**B22 hawaiiite**

Quite altered with carbonate occurring in veins. Original olivine phenocrysts have been extensively altered to orange iddingsite?. The fine grained groundmass consists of subhedral plagioclase laths, opaques and glass. The alteration and presence of carbonate indicates sample is unsuitable for chemical comparison.

**B23 basanite**

Subhedral equant to elongate olivine phenocrysts, otherwise like B22 with less alteration.

**B24, B25 hawaiiite**

Euhedral, equant olivine phenocrysts in a granular groundmass of fine to medium grained olivine. The olivine is considerably altered red-brown around edges of grains and along fractures. The groundmass consists of euhedral plagioclase laths, small euhedral brownish augite and opaques. Alteration of the olivine and along fractures make this sample unsuitable for chemical comparison. B25 shows much less alteration of the groundmass

olivine.

**B26 alkali olivine basalt**

Abundant medium to fine euhedral olivine phenocrysts in a fluidal textured fine granular groundmass of elongate euhedral plagioclase laths, equant augite and opaques.

**B27 alkali olivine basalt**

Olivine phenocrysts in a fine to medium grained granular groundmass of elongate euhedral plagioclase, equant augite, and opaques. Extensive alteration of the phenocrystal olivine and presence of approx 20% modal zeolite make this sample unsuitable for chemical comparison.

**B28, B30 alkali olivine basalt**

Abundant euhedral elongate to equant olivine phenocrysts in a fine grained groundmass of plagioclase, augite and dark brown isotopic glass. Extensive alteration of the phenocrystal olivine and zeolite filled vesicles make this sample unsuitable for chemical comparison. B30 has fewer phenocrysts.

**B31 alkali olivine basalt**

Euhedral elongate to equant olivine phenocrysts as in B28 in a glassy groundmass of with minor fine plagioclase laths.

## Planktic Ostracodes from the Antarctic and Subantarctic Collected by the 1989-1990 Italian Antarctic Expedition

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**ABSTRACT.** Eleven species of planktic Ostracoda were collected by the Italian Antarctic Expedition of 1989-1990 from the region south of New Zealand in the Southern Ocean to the Ross Sea, Antarctica. Of these species, only *Proceroecia rivoltella* n.sp. (described herein) and *Gigantocypris muelleri* were not recorded by Deevey (1982) from much the same area. Depth distributions are given for the more commonly encountered taxa, *Alacia belgicae*, *A. hettacra*, *Boroecia antipoda*, *Metaconchoecia skogsbergi* and *M. isocheira*. Much of the total Ostracoda density at each station is due to the dominance of *A. hettacra* at lower latitudes and *A. belgicae* at higher latitudes. The near identity with Deevey's records confirms that the planktic ostracodes of far southern latitudes are now reasonably well known, at least to depths less than 1000 m.

BENASSI, G., I. FERRARI, P. MENOZZI & K.G. McKENZIE, 1994. Planktic ostracodes from the antarctic and subantarctic collected by the 1989-1990 Italian Antarctic Expedition. Records of the Australian Museum 46(1): 25–37.

Planktic ostracodes of the antarctic and subantarctic are being studied at the Istituto di Ecologia (University of Parma) as part of the continuing biological program of the Italian 'Progetto Antartide'. Our initial work was done on samples collected in 1987-1988 mainly from the nearshore waters of Terranova Bay, the Ross Sea, in the vicinity of the Italian base. It revealed the predominance at all stations and all depths of *Alacia belgicae* (Mueller, 1906) in a species-poor ostracode fauna which also included *Alacia hettacra* (Mueller, 1906) and *Metaconchoecia isocheira* (Mueller, 1906) (McKenzie *et al.*, 1990; Benassi, Naldi & McKenzie, 1992). We noted

that these species are the same as those previously collected in the Ross Sea around the turn of the century (Brady, 1907; Barney, 1921).

This report presents species determinations, description of a new species, and discussion of the planktic ostracodes collected during the 1989-1990 Italian Antarctic Expedition. As such, it supplements previous work on the *RV Eltanin* collections by Deevey (1982). Our primary data – the per sample species list, total Ostracoda density and density for each species – are available as Appendices I and II in another report (Benassi *et al.*, 1992).



## Materials and Methods

Zooplankton samples were collected under the supervision of Prof. L. Guglielmo (University of Messina) in the Southern Ocean and Ross Sea, over an extensive area between 51° and 75°S from 25 November 1989 to 12 January 1990 (Figure 1; Table 1 [Appendix]). An Eznet Bioness apparatus equipped with ten 500 µm mesh nets was used, the net mouth area being 0.25 m<sup>2</sup>. At each station, samples were collected from nine different depth layers, and an integrated sample from the maximum sampling depth to the surface was also taken. This maximum sampling depth was 1000 m; frequently the bottom depth at a station was much greater than this

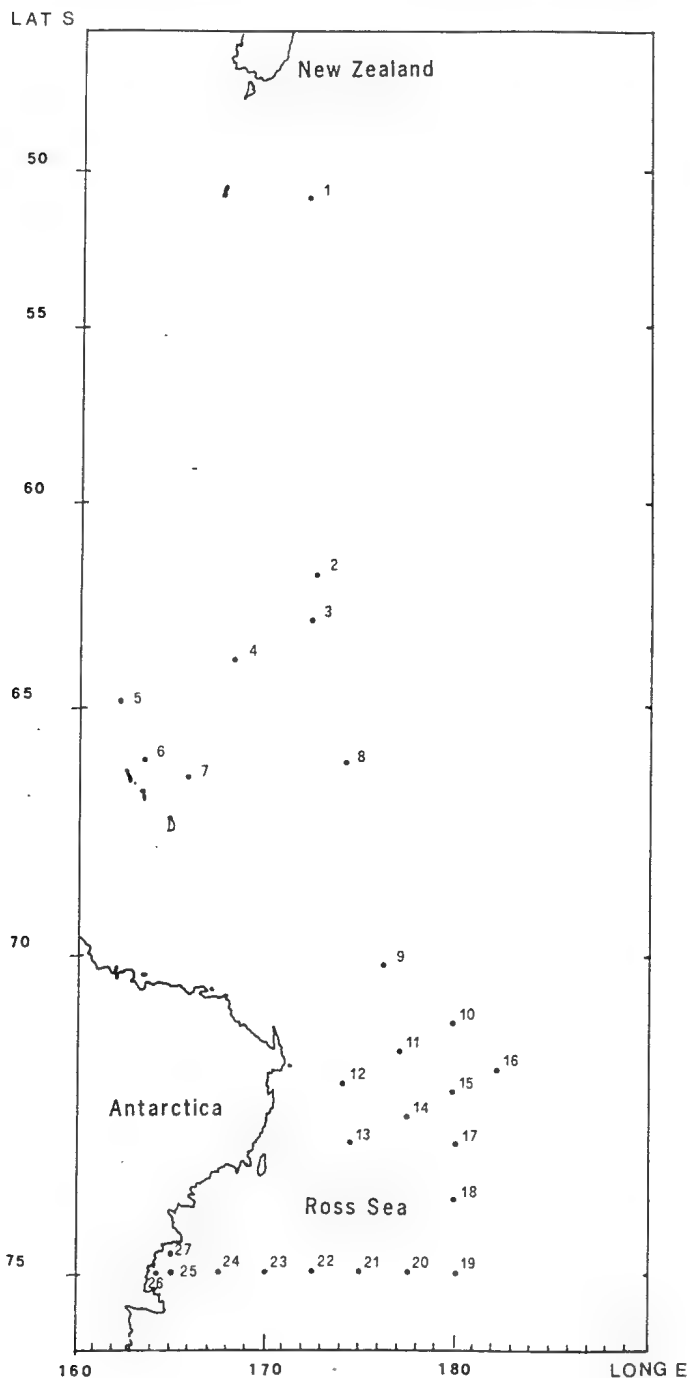


Fig. 1. Locations of sampling stations.

(Table 2 [Appendix]). A total of 572 samples was collected at 58 stations; only 4 of these stations (24, 25, 26 and 27) were located in the sampling area of the 1987-88 Expedition.

Ostracoda were sorted at the Italian Marine Sorting Center, Istituto Scienze Ambientali Marini (University of Genova). We received 346 Ostracoda samples from 48 stations (Table 2 [Appendix]). A total of 6668 specimens were examined individually, and species determinations were made, for juveniles as well as adults, using Mueller (1906), Poulsen (1973), Martens (1979) and Angel (1981). A few poorly preserved or damaged specimens were not identified. The total water volume data was also made available, allowing computations of the density for total Ostracoda and for each species (Table 2 [Appendix]). The presence/absence at each station of the 11 species we identified is summarised in Table 3 (Appendix).

## Notes on the Species

*Gigantocypris muelleri* Skogsberg, 1920. Only one specimen (length 18.02 mm) was found, in sample 7 from station 3, about 69°30'S. According to Angel (1981), this is a bathypelagic species. Its presence south of the Antarctic Convergence seems worth recording, since Deevey (1982) did not find it.

*Conchoecissa symmetrica* (Mueller, 1906). We identified only four individuals in the samples, from stations 2, 4 and 9 respectively. It is noted as occurring frequently from 33° to 68°S in the south Pacific (Deevey, 1978) and between 47° to 64°S in the southern Indian Ocean (Deevey, 1982).

*Boroecia antipoda* (Mueller, 1906). This species was fairly abundant in a large number of samples from station 2 (63°S) to station 17 (73°S). According to Angel (1981), it is a mesopelagic species reported from all oceans at austral latitudes. Deevey records it from 49° to 77°28'S at depths up to 5190 m (Deevey, 1982, table 1).

*Alacia belgicae* (Mueller, 1906). As noted earlier, this was the predominant species among those collected in Terra Nova Bay, the Ross Sea, during the 1987-1988 Italian Antarctic Expedition. In 1989-1990, it occurred from station 10 (about 71°S) to the Ross Sea stations (75°S) and was numerically dominant from station 16 to station 27. Deevey (1982) reports its presence from 63° to 78°S.

*Alacia hettacra* (Mueller, 1906). Like the previous species, it was reported from the Ross Sea by McKenzie *et al.* (1990). In 1989-1990, it was found in almost all the stations and was clearly dominant between station 2 (62°S) and station 11 (72°S). Deevey (1982) cites its occurrence from 50°04' to 78°S.

*Discoconchoecia elegans* (Sars, 1865). This species occurred in nine samples from four stations (1, 2, 3 bis and 4). It is a mesopelagic, transoceanic and cosmopolitan species (Angel, 1981) recorded up to 65°S by Deevey (1983). We foreshadow here that *D. elegans* was the

predominant species collected in the Straits of Magellan by the 1991 Italian Antarctic Expedition.

*Pseudoconchoecia serrulata* (Claus, 1874). This species was found only at stations 1 and 2 but occurred in considerable numbers. It is a mesopelagic species (Angel, 1981), reported in the south Pacific between 40° and 68°S (Deevey, 1978) and in the southern Indian Ocean between 34° and 64°S (Deevey, 1982).

*Obtusoechia antarctica* (Mueller, 1906). It occurred only at station 1 in two samples and in a small number of individuals. We follow Martens (1979) and Deevey (1982) in ascribing the species to Mueller, although in Deevey's final report (Deevey, 1983) it appears as the more familiar *O. obtusata* (Sars, 1866) *antarctica* Mueller. Deevey (1983, table 1) records it between 36° to 65°S. Additionally, McKenzie (unpublished data) has found it off south-western Australia in latitudes dominated by the West Wind Drift, as part of collections made by SS *Diamantina* during the International Indian Ocean Expedition of the 1950-1960s.

*Proceroecia rivoltella* n.sp. [cf. Systematic Description].

*Metaconchoecia skogsbergi* (Iles, 1953). A few individuals of this species were reported in samples collected from the Ross Sea during 1987-1988 (McKenzie *et al.*, 1990). In the 1989-1990 collections, it occurred frequently from station 1 (51°S) to stations 14 and 15 (about 73°S).

*Metaconchoecia isocheira* (Mueller, 1906). Reported as a common species in the Ross Sea by McKenzie *et al.* (1990). In the 1989-1990 Expedition, it was found frequently from 64°S (station 4) to 75°S (Ross Sea stations). Angel (1981) considers it an upper mesopelagic species at austral latitudes in all the oceans and Deevey (1983) records it from 61° to 70°S at 0 to 2000 m.

## Systematic Description

### Halocypridae

### Conchoeciinae

### *Proceroecia* Kock, 1992

**Type species.** *Proceroecia microprocera* (Angel, 1971).

**Amended diagnosis.** Conchoeciine genus in which the shells are small to moderate sized (up to 1.8 mm in length), relatively thin and fragile, striated, with asymmetric compound glands in the usual places (ie, posterodorsal in the LV, posteroventral in the RV), but lacking lateral corner glands and with dorsomedial glands only in the males, plus abundant medial glands along virtually the entire free margins of the valves. Usually, the RV carries a minute posterodorsal spinule.

In the soft anatomy: 1. The cap of the frontal organ in males carries long hairs ventrally and is more or less rounded terminally; in females, the frontal organ is long and slender, the cap is indistinctly jointed from the stem

and is adorned with short prickly hairs ventrodistally.

2. The female antennule is short and without a dorsal bristle on the second segment; the 'e' bristle of the male has an armature consisting of biserial slender or blade-like, backwards-directed spinules.

3. The pipe bristles of the antennal endopod are relatively long in females but much shorter in males; both male endopod clasping organs are recurved strongly and stout proximally, the right one being better developed.

4. The masticatory pad of the mandible coxale is subrectangular, densely spinulose, undivided and straight-edged ventrally; the mandible exopod is well developed, its basal part resembling a cocked pistol in lateral profile; the first endopod segment of the mandible endopod carries at most only 2 (usually none or 1) long annulate ventral bristles, with or without up to 3 associated minute setules, usually set on a lunate ventrodistal bulge.

5. The furca is without a dorsal bristle.

**Remarks.** Poulsen (1973) included the 'procera' group of Mueller (1906) in his very broad interpretation of the genus *Paraconchoecia* Claus, 1891, based on a perceived general similarity in the masticatory pad of the mandible coxale.

The type species of *Paraconchoecia* is *Paraconchoecia oblonga* (Claus, 1890). We note further that *P. gracilis* (Claus, 1890), another of the four species including *oblonga* that were originally assigned to *Paraconchoecia* by Claus (1891), is generally regarded as a junior synonym of *Conchoecia elegans* Sars, 1866, which was made the type species of a new genus *Discoconchoecia* by Martens (1979).

In the strict sense, *Paraconchoecia* comprises only *P. oblonga*, *P. spinifera* (Claus, 1890) and *P. allotherium* (Mueller, 1906). It is simply differentiated from *Proceroecia* by having smooth (not striated) valves, and three or four ventral bristles without associated minute setules on the first endopod segment of the mandible which, unlike the case in *Proceroecia*, does not display a more or less lunate ventrodistal bulge.

*Discoconchoecia* Martens, 1979 is most easily distinguished from *Proceroecia* by the disc-like armature of the male antennule 'e' bristle, and by the fact that the first endopod segment of the mandible has two or three ventral bristles without any associated minute setules.

All other species brought by Poulsen (1973) into the aegis of *Paraconchoecia*, and thereby associated with *Proceroecia* by having a similar undivided, ventrally straight-edged masticatory pad on the mandible coxale, have four ventral bristles without any associated minute setules on the first endopod segment of the mandible; apart from several other differentiating features, including size, type of reticulation, positions of the asymmetric compound glands, shape of the male clasping organs, etc.

Additionally, *Proceroecia* species (= 'procera' group of Mueller, 1906) are identified rather readily by the mandible exopod, with its distinctive cocked-pistol

lateral profile basally and long pilose extruding bristle, a feature which also provides a convenient name for our new species.

*Proceroecia* includes at least the following species: *P. rivoltella* n.sp.; *P. procera* (Mueller, 1894); *P. brachyaskos* (Mueller, 1906); *P. decipiens* (Mueller, 1906); *P. vitiazii* (Rudjakov, 1962); *P. macroprocera* (Angel, 1971); *P. microprocera* (Angel, 1971); *P. hoensis* (Poulsen, 1973). Recently, Angel (personal communication, June 1992) has provided a lengthy list of occurrences determined as *P. brachyaskos* in deep waters of the Atlantic Ocean at tropical latitudes. The mandibular endopod (first segment) of this taxon needs to be rechecked as it may well represent yet another species of *Proceroecia*.

***Proceroecia rivoltella* n.sp. McKenzie & Benassi**

Figs 2-3

**Dimensions.** HOLOTYPE, Museum of Natural History, University of Parma reg. no. 994/1, male, length [L] 1.49 mm, height [H] 0.725 mm, breadth [B] 0.675 mm, length to base of shoulder [S] 0.85 mm (Sample 6/3).

PARATYPES, Australian Museum P42286 – damaged female, L 1.42 mm, H 0.705 mm, S 0.825 mm (Sample 6/3); mature male, L 1.53 mm, H 0.765 mm, B 0.69 mm, S 0.86 mm (Sample 6/3). Other paratypes held in the working collections, Oceanographic Unit, Institute of Ecology, University of Parma – female, length 1.55 mm, height 0.705 mm, breadth 0.650 mm, length to base of shoulder 0.90 mm (Sample 7/3 bis); ovigerous female, L 1.59 mm, H 0.76 mm, B 0.710 mm, S 1.00 mm (Sample 6/2); damaged female, L 1.585 mm, H 0.745 mm, B 0.745 mm, S 0.98 mm (Sample 7/3 bis); damaged male, L 1.40 mm, H 0.63 mm, B 0.59 mm, S 0.84 mm (Sample 7/3 bis); juvenile female, L 1.235 mm, H 0.59 mm, B 0.59 mm, S 0.775 mm (Sample 7/3 bis); juvenile female, L 1.235 mm, H 0.59 mm, B 0.55 mm, S 0.78 mm (Sample 7/3 bis); juvenile male, L 1.27 mm, H 0.55 mm, B 0.49 mm, S 0.805 mm (Sample 5/2); juvenile male, L 1.18 mm, H 0.51 mm, B 0.51 mm, S 0.745 mm (Sample 10/2).

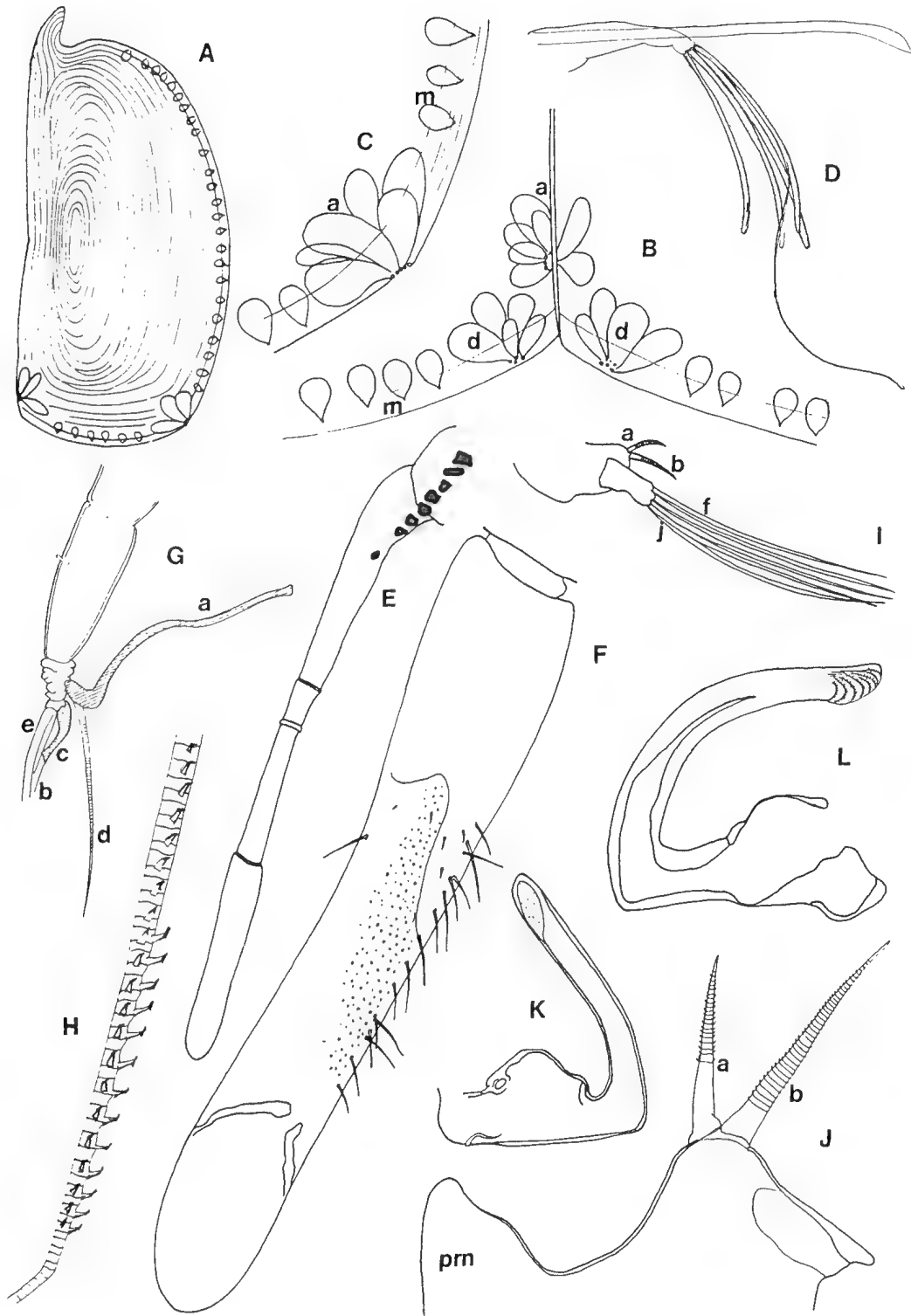
**Description.** *Shell* (Fig. 2B-C) of the male regularly shaped; greatest height posterior of the middle and about 45-50% of the length; surface ornamented distinctively by concentric striations; rostrum arched with a rounded tip, incisure moderately deep and rounded, opening out towards the broadly rounded anteroventral margin; no selvage bulge; ventral margin evenly convex, with a slight protrusion posteroventrally (at the site of the asymmetric compound gland) in the RV, this protrusion not present in the LV; posterior margin broadly and evenly rounded; dorsal margin weakly concave from the posterodorsal area to the base of the shoulder, but straight to weakly convex from this point to the rostrum (the shoulder, therefore, is only moderately developed); greatest shell length is measured from the tip of the rostrum to level with the mid-posterior; greatest breadth posteromedial, ranging from a little less than to equal the height;

asymmetric compound glands in the usual positions (posteroventral in RV, posterodorsal in LV); lateral corner glands absent; dorsomedial glands in the males only, opening posterodorsally on the posterior margin; the ventral and posterior margins, from below the incisure posteriorly, are lined with numerous small subcircular medial glands.

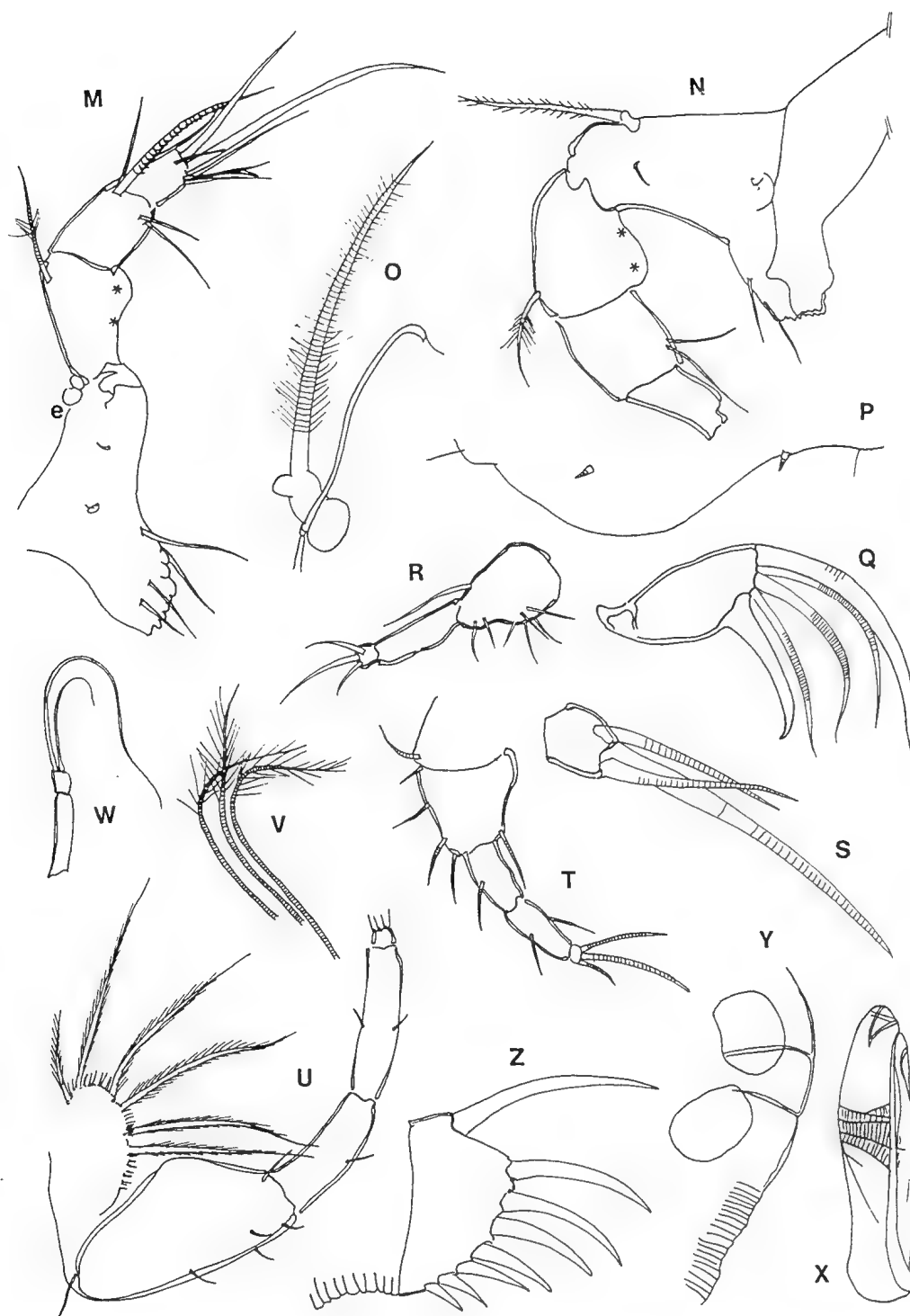
*Antennule* (Fig. 2G-H). Both right (R) and left (L) antennules united proximally with the shaft of the frontal organ, which is further linked to them by a simple circlet attached mediodorsally to the second segment of each antennule (the arrangement is best observed in ventral view); scattered erythrophores can be seen in the ventral part of the first segment of each antennule and at the region of juncture with the stalk of the frontal organ. First and second antennule segments without any bristles; comparative lengths 330  $\mu$ m and 250  $\mu$ m respectively; terminal segment (or segment complex) short and bearing 5 bristles but no dorsal bristle. The 'a' bristle is a 'pipe' bristle, slightly broadened at its base and S-shaped proximally with a length of about 365  $\mu$ m, the 'b' bristle is comparatively short and annulate with a length of 315  $\mu$ m, the 'c' bristle is a very short (100  $\mu$ m or less) 'pipe' bristle which is broadened basally; the 'd' bristle is longer and bent abruptly at about 75% of its length from its base, its total length being 585  $\mu$ m; the 'e' bristle is very long (845  $\mu$ m) and ornamented with a double row of 12-13 blade-like spines, pointing upwards and backwards along the bristle, plus 7-8 uniserial similar spines more proximally, this bristle also is annulate and flexes outwards where its ornament of spines terminates. The 'e' bristle armature is reminiscent of *P. brachyaskos* (Mueller, 1906).

*Frontal organ* (Fig. 2E-F). Shaft about 450  $\mu$ m in total length, with a distinct suture about medially (proximal part 225  $\mu$ m, more distal part 215  $\mu$ m); distally of this suture about 40-50  $\mu$ m it is attached by a simple circlet to the inner dorsal margin of the second segments of the R and L antennules; cap has a length of 215  $\mu$ m, is clearly separated from the shaft, and displays a well-rounded tip; in ventral view shape is digital and completely regular, but viewed laterally is seen to be slightly bent towards the front; bears scattered hairs ventrally.

*Antenna* (Fig. 2J-L). Muscular protopod has the characteristic halocyprid wedge-like shape and is 725  $\mu$ m in length; exopod modified as a natatory structure, with the first segment about 255  $\mu$ m long while segments 2-8 (all very short) total about 140  $\mu$ m in length; the natatory bristles are up to 785  $\mu$ m in length and are characteristically annulate and feathered; the endopod first segment is about as high as it is long (length 150  $\mu$ m) with a conical processus mamillaris proximally, and a lunulate bulge distally on which latter are the 'a' and 'b' bristles; the 'b' bristle is about a third again as long as the 'a' bristle, both are annulate and appear to be adorned with minute hairs; second segment of the endopod is relatively short (about 65  $\mu$ m), carrying 7 bristles; the 'e' bristle is minute, the 'c' and 'd' bristles both are short, the 'h', 'i' and 'j' bristles are sensory



**Fig. 2.** A – shell of adult ovigerous female, x40 (paratype, sample 7/3 bis); B – posterior of adult male shell, LV asymmetric compound gland (a), dorsomedial glands (d), medial glands (m), x125 (holotype, sample 6/3); C – posteroventral margin of adult male RV, asymmetric compound gland (a), medial glands (m), x125 (holotype). All subsequent figures are of the same female paratype and male holotype. D – female A1 (antennule) and frontal organ, x125; E – male frontal organ (ornament of cap not shown), indicating position of erythrophares, x125; F – male frontal organ cap, detail, x500; G – male A1, detail of location position of erythrophares, x125; H – male A1 (antennule), detail of ‘e’ bristle armature, x500; I – female A2 endopod, showing ‘a’, ‘b’, and ‘f-j’ bristles, x125; J – male A2 endopod, processus mamillaris (pm) and ‘a’, ‘b’ bristles, x500; K – male A2 left (L) clasper, x500; L – male A2 right (R) clasper, x500.



**Fig. 3.** M – female mandible, basale and endopod, showing location of exopod (e) and sites of minute setules (\*) of the ventral first endopod segment, x125; N – male mandible general view, coxale, basale and endopod, showing minute epipodial bristle on medial hump of basale (near the coxale), exopod, and sites of minute setules (\*) of the ventral first endopod segment, x125; O – male mandible, exopod showing the pistol-like proximal part and setal pilosity, x500; P – male mandible, detail of lunate bulge of ventral first endopod segment and its 2 minute setules x500; Q – male maxillule, second endopod segment (the ‘hand’), detail of terminal claws and bristles, x500; R – female P1 exopod, x125; S – male P1 exopod third segment, detail of terminal bristles, x500; T – female P2 exopod, x125; U – male P2 epipod (detail of some Strahlen) and exopod (terminal bristles not shown), x125; V – male P2, detail of ends of reflexed terminal bristles, x125; W – female P3, x125; X – penis, x125; Y – female posterior of body, showing large eggs, x125; Z – male furca, x125.

bristles and subequally long (150  $\mu\text{m}$ ), the 'f' bristle measures about 685  $\mu\text{m}$  and the 'g' bristle is distinctly longer (785  $\mu\text{m}$ ), both the 'f' and 'g' bristles are annulate and smooth; the clasping organ is dimorphic on the R and L antennae; the R antennal endopod is larger and curved back regularly and strongly; the L antennal endopod has a generally similar shape but is reflexed more acutely and is smaller; on both organs (R and L) tip is weakly retrousse and rounded terminally; on the R organ it bears several ventral corrugations which form an oval pad; whereas on the L organ the oval pad occurs but is minutely spinulose and does not show any corrugations.

**Mandible** (Fig. 3N-P). Coxale masticatory pad consisting of a densely-hirsute squared-off plate; above it what appear to be 2 minutely spinulose overlapping flaps; more proximally and laterally is a rounded structure off which radiate 4 rather broad-based subacuminate molar claws, behind these is a dense cluster of many (over 20) annulate spikes (the overall appearance is rather like a pincushion); proximal tooth list, below the masticatory pad, has a broad and flat anterior tooth followed after a brief gap by 4 conical teeth, then becoming denticulate and tapering away and up to the rear; median tooth list has a prominent pointed anterior tooth, the list then becomes denticulate and ends posteriorly with 2 stout teeth rather close together; distal tooth list begins anteriorly with a blade-like tooth then becomes denticulate and ends with a relatively powerful pointed tooth; the triangular anterior condyle is well chitinated; overall length of the coxale, from its base to the upper condyle is about 240  $\mu\text{m}$ . Basale wedge-shaped, oriented at right angles to the coxale and highest proximally at its meshing with the coxale, its length is 275  $\mu\text{m}$ ; the basis is dentate and has a well-developed ventral tooth; on the anterior side of the basis are 2 moderately long annulate bristles set well apart, about level with the higher but set medially are 2 shorter annulate bristles, and medially, towards the juncture with the first endopod segment is a small annulate bristle. Epipod a minute bristle extruding from an oval depression on the epipodial hump, near the coxale. Exopod distinctive; shaped like a cocked pistol proximally but terminating as a rather elongate pilose bristle. Endopod 3-segmented; first endopod segment 140  $\mu\text{m}$  in length with a single annulate dorsodistal bristle, adorned medially by radiating spiky hairs, plus a prominent lunate bulge ventrodistally which bears 2 minute setules; second segment 100  $\mu\text{m}$  long, with 2 unequal smooth annulate ventrodistal bristles, plus 3 unequal annulate dorsodistal bristles, 2 of them slender and smooth, the third powerful with spiky hairs; third segment 90  $\mu\text{m}$  long and carrying 7 annulate terminal bristles – 1 rather short and smooth and set mediodorsally, 3 longer, slender and smooth, set ventrodistally, another like these but hirsute and set medioventrally, and 2 powerful but unequal bristles (the larger about one third longer than the smaller), both adorned with stiff spiky hairs.

**Paragnath.** Widest proximally and linguiform, clothed

distally on its inner surface with 9-10 long hairs.

**Front of the head.** Conical in lateral view, trending anteroventrally; rounded in front, gently convex ventrally and gently concave dorsally; in lateral view 275  $\mu\text{m}$  long and 315  $\mu\text{m}$  high. Viewed from below it is broad and flat in front; posterior part of the upper lip has a small central notch in the median element, while the rake-like processes on either side each have 2 relatively coarse inner teeth and a row of 6-8 similarly sized outer teeth.

**Maxillule** (Fig. 3Q). First endite with 7, mainly spine-like, terminal bristles, the anteriormost adorned with spiky hairs; second endite with 8-9 mainly spine-like terminal bristles, the anteriormost subfalcate, plus 2 more proximal bristles on the inner side; additionally, there are 1-2 longish bristles set just above the margin of the palp but projecting downwards along it; palp (endopod) first segment quite wide with respect to its length, carrying 5 unequal dorsal annulate bristles and 3 annulate ventral bristles, plus at least 1 annulate median bristle; second segment hand-shaped and directed backwards, with 5 curved unequal terminal bristles, 3 of these coarser and claw-like, the intervening 2 slender.

**P1** (Fig. 3S). Subpediform; epipod tripartite with 3 sets of Strahlen numbering 5, 5 and 5 respectively from upper to lowermost; protopod rectangular; first endite with 1 short and 1 long annulate bristle, well separated, the latter hirsute; second endite with 3 bristles, 1 short and claw-like, the other 2 unequal but both are annulate and carry long hairs; endopod uni-segmented, plump, with 5 terminal bristles (2 more powerful than the rest and claw-like), plus 3 annulate bristles on the inner side of the ventral endopod; exopod 3-segmented; first segment with 3 proximoventral, 2 medioventral, 2 ventrodistal and 1 dorsodistal bristles (the latter being largest); second segment with 2 medioventral bristles; third segment with 3 unequal terminal bristles; lengths of the segments 140  $\mu\text{m}$ , 130  $\mu\text{m}$  and 20  $\mu\text{m}$  respectively.

**P2** (Fig. 3U-V). Subpediform, reflexed backwards and upwards; epipod tripartite with 3 sets of Strahlen numbering 7 (one small), 5 and 5 respectively; endopod with a single distal bristle; exopod 4-segmented; first segment with at least 4 small medioventral and ventral bristles plus 1 dorsodistal bristle; second segment with 1 small medioventral bristle; third segment with a small bristle medially on each side; fourth segment with 3 long flexuous annulate terminal bristles which are clothed with long hairs distally and have a length of 650  $\mu\text{m}$ ; lengths of the exopod segments are 235  $\mu\text{m}$ , 160  $\mu\text{m}$ , 175  $\mu\text{m}$  and 20  $\mu\text{m}$  respectively. The sex dimorphism of this limb is characteristic for all halocyprids.

**P3.** Reduced and 2-segmented; second segment smaller, but slightly more expanded than the first segment, and carrying 2 very unequal terminal bristles, the much-longer of them whip-like and strongly recurved.

**Penis** (Fig. 3X). Finger-shaped, relatively wide, and 245  $\mu\text{m}$  in length, with a few (4-5) medial transverse muscle bands.

**Furca** (Fig. 3Z). Lamellar and bearing 8 claws, the



first of these is the largest and separated from the others by a distinct gap, the second and third claws are subequal, the fourth to eighth claws reduce regularly in size.

**Female. Shell** (Fig. 2A) resembles that of the male, but does not have posteroventral dorsomedial glands. Female antennules do not have a circlet connecting them with the frontal organ (Fig. 2D); each antennule carries 5 terminal bristles of which 4 ('a'-d') are 'pipe' bristles and subequally long, while the 'e' bristle is longer and slender with fine lateral hairs. The cap of the frontal organ in the female is not clearly differentiated from the stalk, terminates in a pointed tip and is finely pilose ventrally. On the endopod of the female antenna [Fig. 2I], setae 'c' and 'd' are missing; 'e' is minute and 'f' is only slightly longer than 'g', 'h', 'i' and 'j', all ('f'-j') are sensory; and there is no clasping organ. The mandible (Fig. 3M), maxillule and P1 (Fig. 3R) are all similar to those of the male, except that the epipod of the P1 carries fewer Strahlen, 4, 3 and 4, although their arrangement remains tripartite. The P2 in the female (Fig. 3T) is again very similar to that in the male but smaller, also the bristles of exopod segments 1, 2 and 3 are all stronger than in the male, and the 3 terminal bristles of the fourth segment are unequal, the strongest being claw-like; on the first exopod segment of the P2 the chaetotaxy is 2 medioventral, 2 ventrodistal and 1 dorsodistal. The P3 (Fig. 3W) and furca resemble those of the male. Adult females are easily recognised through the translucent valves because they are usually ovigerous; when first formed the eggs are small and densely packed, when released they about double their volume (large eggs) (Fig. 3Y).

**Etymology.** *Rivoltella* (Italian) = pistol, for the shape of the proximal mandible exopod.

**Remarks.** As noted earlier, the new species belongs among a small group of conchoeciines, the 'procera' group of Mueller (1906) [see also Angel, 1971] which Poulsen (1973) brought into *Paraconchoecia* Claus, 1891. Reprising, this species group is characterised by asymmetric compound glands in the usual conchoeciine position, the absence of lateral corner glands, the occurrence of posterodorsal dorsomedial glands only in males, abundant medial glands along virtually the whole free margin below the incisure, the absence of a dorsal bristle on the furca, the occurrence of at most two annulate bristles with or without associated minute setules on a prominent ventral bulge of the first endopod segment of the mandible, and a straight-edged, densely hirsute masticatory pad on the mandible coxale.

Our new species shares these features but is readily distinguished from others in the group by the single long annulate bristle and two minute setules on the lunate bulge of the first endopod segment of the mandible and the relatively short 'b' bristle of the male antennule (these features are readily observed at ordinary binocular magnification by removing the antenna from

one side of the animal). Of the other 'procera' group species, *P. procera*, *microprocera* and *macroprocera* all have one long annulate bristle ventrally on the first mandible endopodite segment, but no minute setules (Angel, 1971), *P. brachyaskos* has one and *P. decipiens* has two long annulate ventral bristles (Poulsen, 1973), but no minute setules; *P. vitiazi* Rudjakov, 1962 has one such bristle plus three minute setules (Angel, 1971); *P. hoensis* Poulsen, 1973 has neither long annulate bristles nor setules (Poulsen, 1973). In all these other species, the 'b' bristle of the male antennule is nearly as long as the 'd' and 'e' bristles.

It is interesting to note that our most southerly record of *P. rivoltella* (about 71°S) was taken at 200 to 160 m in near surface waters; whereas the specimens found at 68°35'S were collected at 800 to 700 m depth; and the specimens from about 66°S were taken at depths between 1000 and 700 m. Since the Antarctic Convergence in this part of the Southern Ocean oscillates between 60° and 65°S, *P. rivoltella* probably follows antarctic water down the gradient at the boundary region. Now that it has been described and differentiated from other species in the 'procera' group, therefore, we expect that *P. rivoltella* will be determined in the deepwater zooplankton of the southern oceans at more northerly latitudes and, indeed, could become an index for tracing the movement of antarctic water into these latitudes.

## Discussion

Our data allow a more detailed analysis of depth distributions for the species we identified. First we considered the set of 11 stations (2 to 15 bis) located between about 62° and 73°S (Table 2). The highest density values at these stations were observed for *Alacia hettacra* between 100-300 m, for *Boroecia antipoda* between 300-600 m and for *Metaconchoecia skogsbergi* between 500-600 m. A second set of 17 stations (11 bis to 27) between about 71°30' and 75°S was analysed similarly. Results showed that the highest densities were observed for *Alacia belgicae* between 100 and 500 m, *A. hettacra* between 0 and 300 m, and *Metaconchoecia isocheira* from 200 and 500 m. Thus, it appears that at higher latitudes and inshore *Alacia belgicae* dominates over *A. hettacra* at most depths, and *M. isocheira* is the other common species; whereas offshore and at lower latitudes (but still about 62°S or greater), *A. hettacra* dominates the surface waters while *M. skogsbergi* and *B. antipoda* take over at middle depths.

The maximum density values of total Ostracoda at each station are given in Table 3. They exceed 100 individuals/100 m<sup>3</sup> in 20 of the 48 stations. As indicated by the analysis of depth distributions given above, these densities are accounted for mainly by *A. hettacra* at lower latitudes and *A. belgicae* at higher latitudes.

Undoubtedly, more species would have been taken if the sampling program had incorporated depths greater

than 1000 m and stations located in lower latitudes. Also, the relatively large mesh size (500  $\mu\text{m}$ ) probably favoured the escape of small species (for example in *Metaconchoecia*) and of small juveniles in larger species.

Our material included only one station (station 1, about 51°S) at a latitude less than around 62°S. Of the 59 halocyprid species reported by Deevey (1982, table 1) from much the same area all but 12 can be discounted, with respect to our material, on the grounds of their usual occurrence either at greater depth or at lower latitudes. Nevertheless, it might appear surprising that *Conchoecilla chuni* (Mueller, 1906), *Procerocia brachyaskos* (Mueller, 1906) and *Gaussicia edentata* (Mueller, 1906) were not taken in 1989-1990.

With respect to these three species, only the absence of the first-named (*C. chuni*) is hard to explain because Deevey (1982) finds it a common species, and earlier (Deevey, 1978) had referred to records by Poulsen from New Zealand waters. On the *RV Eltanin* cruises 27, 32 and 51, which took place during the austral summers of 1967, 1968 and 1972 respectively, it occurred in a total of 19 samples from the same sector (New Zealand to the Ross Sea, 164°30'E to 180°) traversed by the Italian 1989-1990 Expedition, but not below 64°S (Deevey, 1982, table 2). Only 5 stations of the 1989-1990 Italian program were located north of this latitude. The non-occurrence of *C. chuni* at these stations remains surprising since it is normally a shallow-living species (to about 400 m) during summer and is a characteristic southern hemisphere taxon. We note, however, that prior to Deevey's report it had not been recorded below 55°S (Angel, 1981:557).

The absence of *Procerocia brachyaskos* and *Gaussicia edentata*, on the other hand, is not really surprising. Both are deeper water species. Although Deevey (1982, table 1) gives their depth ranges as 0 to 5190 m and 0 to 2780 m respectively she makes it clear that for reasons discussed by her (limitations of field procedures and collecting gear) these "...are therefore not necessarily reliable for some species" (Deevey, 1982:132). For *P. brachyaskos* in particular she notes that it was taken only in one 0 to 1300 m haul and, "may have been a contaminant in the deepest tow obtained" (Deevey, 1982:147). Thus, a more appropriate depth range for *P. brachyaskos* is probably below 1000 m and not as deep as 5000 m. For Angel (1981) it is a lower mesopelagic and bathypelagic species in latitudes up to about 56°30'S. Likewise, Angel (1981) records *G. edentata* as a lower mesopelagic taxon; and Deevey (1983) gives its depth range as 1000 to 2000 m and farthest latitude south (in the Pacific) as 56°S. In the sector traversed by the Italian 1989-1990 Expedition, *G. edentata* was only collected by *RV Eltanin* in one sample at about 63°30'S on cruise 27 in the austral summer of 1967 (Deevey, 1982, table 2). Note also that our new species *P. rivoltella*, because it belongs to the 'procera' group of Mueller (1906) (cf. Poulsen, 1973), prior to our description might well have been determined as *P. brachyaskos* by previous authors, eg, Deevey (1982) and Hartmann (1986). Thus, it can be summarised that

the Italian 1989-1990 program collected virtually the same suite of species over the same area to 1000 m depth as surveyed previously by earlier expeditions, including the cruises of *RV Eltanin*.

This result confirms Deevey's opinion that antarctic and subantarctic ostracodes can now be said to be reasonably well known (Deevey, 1983:409). In a general review of the state of knowledge of Recent Myodocopida, Chavtur (1993) supports such an assessment, qualifying it only by his comment that present understanding of the systematics of such genera as *Metaconchoecia* and *Discoconchoecia* may hide several new species under the old species names.

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## APPENDIX

Table 1. Stations at which zooplankton samples were collected during the 1989-1990 Italian Antarctic Expedition: giving date, mean latitude/longitude, and sampling duration.

Station	Date	Latitude S	Longitude E	Time (hrs)
1	25.11.89	50°56.69'	171°57.76'	1548-1641
2	29.11.89	61°57.89'	172°13.56'	0927-1058
3	01.12.89	63°05.43'	171°57.00'	0847-0955
3 bis	01.12.89	62°58.94'	172°03.66'	1427-1504
4	03.12.89	63°56.57'	168°04.44'	2121-2240
5	05.12.89	64°52.72'	161°54.04'	1038-1210
6	06.12.89	66°05.15'	163°36.24'	1637-1725
7	17.12.89	68°35.55'	176°25.10'	1748-1810
7 bis	17.12.89	68°35.95'	176°26.25'	1847-2012
8	22.12.89	70°40.70'	178°07.60'	0806-0845
8 bis	22.12.89	70°36.95'	178°15.45'	0932-1107
9	21.12.89	70°10.95'	176°23.95'	1313-1437
9 bis	21.12.89	70°10.60'	176°25.65'	1527-1608
10	23.12.89	71°12.00'	179°42.50'	1502-1547
10 bis	23.12.89	71°08.95'	179°53.85'	1630-1802
11	24.12.89	71°37.10'	176°53.85'	1640-1718
11 bis	24.12.89	71°40.20'	176°59.85'	1800-1843
12	25.12.89	72°10.00'	173°57.85'	1434-1508
12 bis	25.12.89	72°12.90'	174°00.10'	1546-1656
13	26.12.89	73°09.35'	174°23.60'	0822-0909
13 bis	26.12.89	73°12.85'	174°23.70'	0951-1027
14	27.12.89	72°44.30'	177°28.35'	0818-0859
14 bis	27.12.89	72°44.10'	177°13.70'	1402-1534
15	28.12.89	72°20.30'	179°53.60'	0821-0855
15 bis	28.12.89	72°19.35'	179°49.45'	0933-1103
16	29.12.89	71°56.90'	177°45.85'	0817-0853
16 bis	29.12.89	71°58.90'	177°55.05'	0931-1050
17	30.12.89	73°09.70'	179°57.35'	0902-0947
17 bis	30.12.89	73°09.80'	179°53.15'	1028-1057
18	31.12.89	73°58.85'	179°56.90'	0825-0854
19	01.01.90	75°00.75'	179°55.85'	1035-1133
19 bis	01.01.90	75°00.60'	179°59.70'	1218-1245
20	02.01.90	74°59.50'	177°30.55'	0815-0847
20 bis	02.01.90	74°59.15'	177°30.70'	0938-1003
21	03.01.90	74°59.40'	175°00.75'	0823-0858
22	04.01.90	75°00.35'	172°30.10'	0811-0914
22 N	03.01.90	74°59.50'	172°35.20'	2300-0002
22 P	04.01.90	74°59.00'	172°32.70'	1617-1724
23	05.01.90	74°59.00'	170°00.80'	0824-0909
23 bis	05.01.90	74°59.85'	170°01.90'	1006-1038
24	06.12.90	74°59.25'	167°27.60'	0828-0927
24 bis	06.01.90	74°58.25'	167°30.35'	1009-1039
25	07.01.90	74°57.50'	165°21.00'	1220-1351
25 bis	07.01.90	74°56.15'	165°22.40'	1434-1511
26	08.01.90	74°56.90'	164°13.45'	1459-1557
26 bis	08.01.90	74°56.70'	164°12.95'	1637-1710
27	12.01.90	74°46.40'	164°53.80'	1101-1210
27 bis	12.01.90	74°46.60'	164°54.80'	1250-1356

Table 2. Bottom depth, maximum sampling depth and number of ostracode samples examined for each station. IS = ostracode density for the integrated sample (collected from the maximum sampling depth to the surface). MX = maximum ostracode density among the samples from different depth layers. Both densities as individuals per m<sup>3</sup>. \* = no integrated sample; \*\* = only an integrated sample.

Station	Bottom	Maximum Depth (m)	No. of Samples	IS	MX
1	517	400	9	11.5	90.9
2	4230	1000	9	14.2	916.8
3	2150	800	5	4.7	22.6
3 bis	3220	200	7	154.6	405.1
4	3125	1000	8	3.8	35.7
5	3130	1000	10	1.8	35.3
6	2700	1000	9	5.3	100.7
7	3505	200	7	17.8	50.0
7 bis	3530	1000	9	13.3	37.6
8	3350	1000	8	29.5	112.6
8 bis	3390	1000	9	*	85.6
9	3285	1000	9	11.6	51.2
9 bis	3290	200	7	16.7	128.8
10	1325	200	10	9.3	71.2
10 bis	1340	1000	10	7.1	39.3
11	940	200	8	7.7	100.0
11 bis	845	800	9	2.8	58.4
12	685	200	5	11.0	18.2
12 bis	575	500	8	22.7	13.0
13	315	280	3	2.4	6.5
13 bis	310	100	1	0.7	**
14	1575	200	6	27.4	97.2
14 bis	1545	1000	9	2.0	258.4
15	2120	200	7	22.8	96.1
15 bis	2140	1000	9	1.5	34.9
16	760	200	9	53.8	325.3
16 bis	750	700	9	28.3	160.9
17	535	450	9	2.4	49.8
17 bis	530	100	2	11.2	8.0
18	280	250	2	4.2	5.8
19	460	400	9	3.2	135.6
19 bis	460	100	5	5.8	11.8
20	390	350	8	4.1	34.5
20 bis	390	100	1	1.6	**
21	300	250	7	6.1	18.7
22	545	500	7	12.6	147.6
22 N	540	450	8	15.1	140.2
22 P	550	500	10	48.2	263.4
23	345	300	10	49.3	185.4
23 bis	345	100	3	103.3	15.2
24	520	450	10	105.4	305.1
24 bis	545	100	4	0.9	22.9
25	885	800	10	92.3	189.3
25 bis	880	200	5	103.4	34.0
26	635	400	10	69.3	378.0
26 bis	590	100	3	15.1	16.8
27	735	600	10	67.7	376.1
27 bis	835	100	4	*	33.6

Table 3. Distribution of the 11 ostracode species in the sampling area. GM = *Gigantocypris muelleri*; CS = *Conchoecissa symmetrica*; BA = *Boroecia antipoda*; AB = *Alacia belgicae*; AH = *Alacia hettacra*; DE = *Discoconchoecia elegans*; PS = *Pseudoconchoecia serrulata*; OA = *Obusoeecia antarctica*; PR = *Proceroecia rivoltella*; MS = *Metaconchoecia skogsbergi*; MI = *Metaconchoecia isocheira*. X = present.

Stn	GM	CS	BA	AB	AH	DE	PS	OA	PR	MS	MI
1	-	-	-	-	-	X	X	X	-	X	-
2	-	X	X	-	X	X	X	-	-	X	-
3	X	-	X	-	X	-	-	-	-	-	-
3 bis	-	-	-	-	X	X	-	-	-	-	-
4	-	X	X	-	X	X	-	-	-	X	X
5	-	-	X	-	X	-	-	-	X	X	X
6	-	-	X	-	X	-	-	-	X	-	-
7	-	-	-	-	X	-	-	-	-	-	-
7 bis	-	-	X	-	X	-	-	-	X	X	X
8	-	-	-	-	X	-	-	-	-	-	X
8 bis	-	-	X	-	X	-	-	-	-	X	-
9	-	X	X	-	X	-	-	-	-	X	X
9 bis	-	-	X	-	X	-	-	-	-	-	X
10	-	-	X	-	X	-	-	-	X	-	-
10 bis	-	-	X	X	X	-	-	-	-	X	-
11	-	-	X	-	X	-	-	-	-	-	-
11 bis	-	-	X	X	X	-	-	-	-	X	X
12	-	-	-	X	-	-	-	-	-	-	-
12 bis	-	-	X	X	X	-	-	-	-	X	X
13	-	-	-	X	-	-	-	-	-	-	-
13 bis	-	-	-	-	-	-	-	-	-	-	X
14	-	-	-	X	X	-	-	-	-	-	-
14 bis	-	-	X	X	X	-	-	-	-	X	-
15	-	-	-	X	X	-	-	-	-	-	X
15 bis	-	-	X	X	X	-	-	-	-	X	X
16	-	-	-	X	X	-	-	-	-	-	X
16 bis	-	-	X	X	X	-	-	-	-	-	X
17	-	-	X	X	X	-	-	-	-	-	X
17 bis	-	-	-	X	-	-	-	-	-	-	-
18	-	-	-	X	-	-	-	-	-	-	-
19	-	-	-	X	X	-	-	-	-	-	X
19 bis	-	-	-	X	X	-	-	-	-	-	-
20	-	-	-	X	X	-	-	-	-	-	X
20 bis	-	-	-	-	-	-	-	-	-	-	-
21	-	-	-	X	X	-	-	-	-	-	X
22	-	-	-	X	X	-	-	-	-	-	X
22 N	-	-	-	X	X	-	-	-	-	-	X
22 P	-	-	-	X	X	-	-	-	-	-	X
23	-	-	-	X	X	-	-	-	-	-	X
23 bis	-	-	-	X	-	-	-	-	-	-	X
24	-	-	-	X	X	-	-	-	-	-	X
24 bis	-	-	-	X	-	-	-	-	-	-	X
25	-	-	-	X	X	-	-	-	-	-	-
25 bis	-	-	-	X	-	-	-	-	-	-	X
26	-	-	-	X	X	-	-	-	-	-	-
26 bis	-	-	-	X	-	-	-	-	-	-	X
27	-	-	-	X	-	-	-	-	-	-	X
27 bis	-	-	-	X	-	-	-	-	-	-	-





## A Review of the Filistatid Spiders (Araneae: Filistatidae) of Australia

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**ABSTRACT.** Two new genera of filistatid spiders from Australia are described. *Wandella* n.gen. is widely distributed in mainland Australia and includes eleven species: *Wandella barbarella* n.sp. (type species), *W. australiensis* (L. Koch, 1873) n.comb., *W. orana* n.sp., *W. murrayensis* n.sp., *W. stuartensis* n.sp., *W. centralis* n.sp., *W. parnabyi* n.sp., *W. alinjarra* n.sp., *W. waldockae* n.sp., *W. pallida* n.sp., *W. diamentina* n.sp. *Yardiella* n.gen. is a monotypic genus for *Yardiella humphreysi*, currently known only from North-West Cape Peninsula. The affinities of these genera with *Pritha* Lehtinen, and Indo-Pacific and Indian filistatid spider faunas are noted.

GRAY, M.R., 1994. A review of the filistatid spiders (Araneae: Filistatidae) of Australia. Records of the Australian Museum 46(1): 39–61.

The filistatid spiders are usually placed with the Haplogynae, araneomorph spiders with simple genitalic structures, as the only cribellate members of this basal neocribellate group. The family relationships of the Filistatidae remain one of the more enigmatic problems of spider phylogeny, exemplified by the differing interpretations of Lehtinen (1986), Eskov & Zonshtein (1990) and Platnick *et al.* (1991). Filistatids have an almost worldwide distribution, with the exception of the north and south cool temperate regions. Twelve genera have been described, and further generic studies and a cladistic analysis of generic relationships are in progress.

Only one species of filistatid spider, *Filistata australiensis* L. Koch, 1873, has been described from Australia. It was based upon female specimens from mid-eastern Queensland. The present study shows that filistatid spiders are widely distributed in Australia, in habitats ranging from arid zone rangelands to rainforest.

Their biology is poorly known. Several species make small, irregular, cribellate sheet webs, with one to four more or less distinct funnel entrances (spiders and webs, Figs 1–6). These webs can be found under loose bark (notably of *Eucalyptus* spp. associated with watercourses), in leaf litter, under rocks, and in caves. Some inland species make soil burrows. J. Henschel (personal communication) has observed cribellate silk triplines radiating from burrow entrances in red dune soils in western Queensland.

### Systematics

Lehtinen (1967) assigned *F. australiensis* to *Pritha* Lehtinen. At present, *Pritha* comprises a loose association of species from the southern Palaearctic, Oriental and Indo-Pacific regions, united by the common possession of a strongly procurved ('horseshoe-shaped') cymbium.

Examination of additional material, especially male spiders, has provided new characters that reveal a related group of genera from the Indian and Indo-Pacific regions. The Australian representatives of this group, described below, include *Yardiella* n.gen. from North-West Cape Peninsula, Western Australia, and *Wandella* n.gen., widespread in mainland Australia. One of the Indo-Pacific genera (Gray, in preparation) has a trans-Pacific distribution including the Torres Strait area of north-eastern Australia. This genus includes *Filistata bakeri* Berland from the Cook Islands and *F. gibsonhilli* Savory from Christmas Island, both currently placed in *Pritha*. Thus restricted, Lehtinen's *Pritha* becomes a southern Palearctic and Oriental genus.

*Wandella*, *Yardiella* and their Indian and Indo-Pacific relatives share two male palpal characters that are absent from *Pritha*. Firstly, the palpal organ has an elongate

dorsal sclerite forming a lamelliform, paraembolic process (Figs 57-64) above the embolus. *Pritha* has a simple rod-like palpal organ (Ledoux, 1977). Secondly, the posttegular palpal surface is armed with either large or minute teeth, the latter disposed in comb-like arrays. These comb-like arrays have been noted in *Wandella* (Figs 80, 81), related Indo-Pacific genera, and the South American genus *Pikelinea* Mello-Leitao. By contrast, the *Yardiella* male palp has larger, irregularly arranged teeth and a uniquely modified paraembolic process with a 'scaliform' dorsal structure (Figs 119-124). This type of paraembolic structure is also present in filistatid spiders from Orissa in north-eastern India (Figs 125, 126). Consequently, *Yardiella* is erected here as a monotypic Australian genus that has affinities with elements of the Indian filistatid fauna.

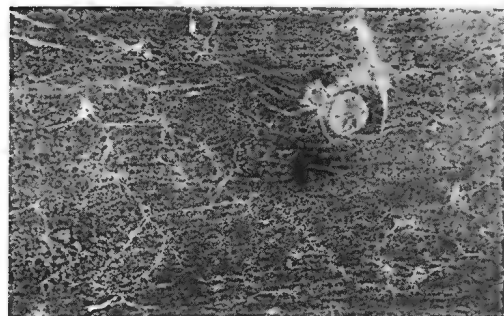
Both character and geographic distributions suggest that these 'prithine' genera shared a common ancestor



1



4



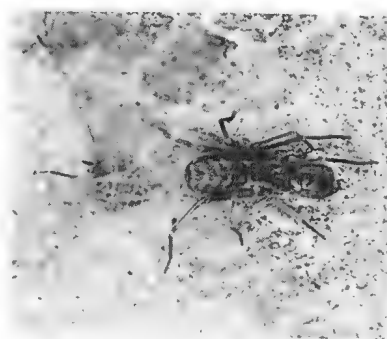
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6

**Figs 1-6.** Spiders and webs. 1,2, *Wandella barbarella*: 1, female; 2, female in sheet web under *Eucalyptus wandoo* bark. 3-5, *W. orana*: 3, male; 4, female in hunting position at tunnel entrance; 5, sheet web with several entrances built on wooden beam in shed. 6, *Yardiella humphreysi* feeding on sheet web.

prior to the breakup of Gondwanaland. The ancestors of *Yardiella* were presumably widespread in western Gondwanaland before the 130 million year old separation of India.

### Notes on Descriptions

All measurements are given in millimetres. For standard data the holotype or allotype measurement is given first, followed (when available) by a range in parentheses.

**Abbreviations.** Morphological characters: L – length, W – width, BL – body length, CL – carapace length, CW – carapace width, AL – abdomen length, AW –

abdomen width, CIL – clypeus length, EGW – eye group width, MOAL – median ocular area length, AME – anterior median eye, ALE – anterior lateral eye, PLE – posterior lateral eye, PME – posterior median eye, Tib1L – leg 1 tibia length, ALS – anterior lateral spinneret, PMS – posterior median spinneret, PLS – posterior lateral spinneret. Specimen repositories: AM – Australian Museum, Sydney; CAS – Californian Academy of Sciences, San Francisco; MNHN – Museum National d'Histoire Naturelle, Paris; NHMW – Naturhistorisches Museum, Wien; QM – Queensland Museum, Brisbane; SAM – South Australian Museum, Adelaide; WAM – Western Australian Museum, Perth; ZMH – Zoologisches Museum fur Hamburg, Hamburg. Australian states: NT – Northern Territory; Qld – Queensland; NSW – New South Wales; Vic. – Victoria; SA – South Australia; WA – Western Australia.

### Filistatidae

#### Key to Australian Genera

1. AME and PME usually subequal. Plumose hairs absent. Male palp with dorsal lamelliform paraembolic process and comb-like arrays of minute teeth on post-tegular surface ..... *Wandella*
- AME much smaller than PME. Plumose hairs present. Male palp deeply grooved prolaterally below thickened paraembolic process; post-tegulum with teeth but comb-like tooth arrays absent ..... *Yardiella*

#### *Wandella* n.gen.

**Diagnosis.** Spines absent. Mid-dorsal carapace stripe bifurcate posteriorly, submarginal bands present. AME and PME usually subequal. Plumose hairs absent. PMS with 2 spigots. Male palp with lamelliform paraembolic process, margin entire or, rarely, ragged terminally. Post-tegular palp armed with numerous comb-like arrays of minute, acuminate teeth. Female genitalia with 4 receptacula embedded in secretory glands, connecting ducts short, straight.

**Description.** Small-medium sized spiders, CL males 0.75-1.75, CL females 0.95-2.40. Carapace with dark and light brown markings (Figs 32, 37). A broad mid-dorsal stripe runs back from eye region narrowing to foveal region, where it bifurcates; stripe dark brown to black in eye region, brown postocular area encloses a smaller and a larger pair of weakly or non-pigmented spots. Brown, scalloped submarginal bands lie inside the unpigmented thoracic margins. Clypeus strongly pigmented laterally, paler centrally. Labium and sternum brown-grey marginally, paler centrally. Cuticle of mouthparts and tarsi of palps and legs 1,2 orange-brown. Leg segments, excluding tarsi, with brown annulations proximally and distally, often joined by longitudinal pigment lines. Abdomen dark brown to grey with

dorsolateral lighter brown patterning in the form of an anterior mid-dorsal stripe and 5-7 more or less distinct, lateral chevron markings. Ventral surface with a midventral, longitudinal, brown stripe broken at spiracular area and enclosing the spinnerets. Carapace ovoid-subcircular, clypeus projecting anteriorly, bluntly rounded in females, narrower and more prominent in males. Eyes on broad tubercle. ALE usually larger than AME, and AME larger than or subequal to PME (AME smallest in cavernicolous species). PME usually separated by more than their diameter. Strong bristles in front of and behind eyes, extending back to the foveal region. Fovea absent. Maxilla with a single row of broad, rather blunt serrula teeth (about 16), and branched chemosensory hairs (Fig. 19). Sternum ovoid, posteriorly pointed. Some species with a pair of small, more or less distinct posterior sternal sigillae (evident as non-pigmented spots in pigmented sternal margin), most obvious in females (Fig. 34). Body and legs clothed with ciliate hairs (Fig. 9). Plumose hairs absent. Legs 4123. Carapace usually 0.75 times or more length of tibia 1 in males, subequal in females. Calamistrum a short, triple row of toothed setae on retrolateral, proximal metatarsus IV. Outer rows usually with 6-10 hairs, middle row with 5-6 hairs. Setae in upper rows with ribbed surfaces, lower row setae with wide, smooth upper surface (Figs 13, 14). Female palpal tarsus usually short and broad. Tarsal organ domed, with irregular concentric ridging, opening via a small

subcentral pore (Fig. 11). Trichobothria in single row on metatarsi and tibiae (Figs 47, 48): metatarsi 1,4 with 1 long distal and 5-6 shorter proximal to central; metatarsi 2,3 with 4-5 proximal to central, distally longest; tibiae with 1 long central and 3-4 shorter proximal. Trichobothrial base with raised circular margin and broad opening with vertically ribbed internal walls (same as for *Yardiella*, Fig. 20). Male palpal tibia more or less incrassate. Cymbium anterior margin deeply procurved (Fig. 59), with long hairs projecting forward over tegulum. Prolateral tegular surface excavated. Ejaculatory duct n-shaped proximally, distal part follows ventral surface of post-tegulum and embolus (Figs 30, 39). Embolus a short, thick rod, usually curved ventrally. Lamelliform paraembolic process with free distal end curved prolaterally over the embolus; margin of process normally entire but distal part sometimes ragged (Figs 57-64). Post-tegular parts of palp with numerous comb-like arrays of minute, procumbent, acuminate teeth (80, 81). Abdomen with 2 pairs of small dorsal sigillae. Female internal genitalia (Figs 95-106) with a pair of more or less globose, lobe-like receptacula on each side, the medial pair smaller and sometimes digitiform (Fig. 98). Each pair of receptacula lobes opens into a bursal pocket arising from the anterolateral margins of the broad common copulatory bursa; lateral receptacula lobes with a short, straight and narrow connecting duct, medial lobe broadly connected. Spermathecae embedded in secretory glands, a greater concentration of glands occurring on the medial lobes. Spinnerets (Figs 24-29) subterminal, rounded posterior abdomen extending beyond them. Cribellum bipartite, tubiform spigots weakly

clavate in distal third (Figs 25, 26). ALS with 1 major ampullate and 20-22 piriform spigots (2 marginal with flat rather than raised bases) (Fig. 27). PMS with 2 separated, flexible, weakly ensiform spigots, posterior spigot longest (Fig. 28). One or both may be paracribellar spigots, in the sense of Platnick *et al.* (1991); both shafts are widened proximally, narrowing markedly to the tip. PLS with 2 spigots (Fig. 29), one elongate with a large base may serve the minor ampullate gland; the smaller spigot may be aciniform. A row of 6-7 short setae are placed across the anterior surface of each ALS (Fig. 24). 6-8 large and small clavate setae are grouped in front of each PMS (Fig. 24); 3-4 large clavate setae surmount each PLS (Figs 24, 28). A pair of spiracles present, each opening at opposite ends of a broad groove placed in front of, but separated from, the spinnerets (about one third distance to epigynal fold); posterior book lungs rudimentary (Fig. 44).

**Type species.** *Wandella barbarella* n.sp.

**Included species.** *Wandella barbarella* n.sp., *W. australiensis* (L. Koch, 1873), *W. orana* n.sp., *W. murrayensis* n.sp., *W. stuartensis* n.sp., *W. centralis* n.sp., *W. parnabyi* n.sp., *W. alinjarra* n.sp., *W. waldockae* n.sp., *W. pallida* n.sp., *W. diamentina* n.sp.

**Distribution.** Mainland Australia (Figs 7, 8).

**Etymology.** The generic name is an Aboriginal word for bark; loose bark is a typical habitat for several species.

### Key to Species of *Wandella*

1. Legs long, thin, 1.5-2 times as long as carapace ..... 2  
 — Legs normal ..... 3
2. AME about as large as PME ..... *W. diamentina*  
 — AME much smaller than other eyes ..... *W. pallida*
3. Male palpal tibia short (less than 1.5 times longer than wide) ..... 4  
 — Male palpal tibia longer than this ..... 5
4. Abdomen with strong band-like chevron pattern ..... *W. stuartensis*  
 — Abdomen with more diffuse chevron pattern ..... *W. alinjarra*
5. Paraembolic lamina distally free, prolaterally curved ..... 6  
 — Paraembolic lamina sessile, erect ..... *W. waldockae*
6. Female carapace broad, subcircular ..... 7  
 — Female carapace narrower, ovoid ..... *W. parnabyi*

- 7. Paraembolic lamina as long as embolus ..... 8
- Paraembolic lamina clearly shorter than embolus ..... 9
- 8. Male palpal tibia long (about 2 times as long as wide) ..... *W. centralis*
- Male palpal tibia shorter than this ..... *W. orana*
- 9. Sternal sigillae present ..... 10
- Sternal sigillae absent or indistinct ..... *W. murrayensis*
- 10. Spermathecae widely separated, divergent (north-east Australia) ..... *W. australiensis*
- Spermathecae more approximated (south-west Australia) ..... *W. barbarella*

***Wandella barbarella* n.sp.**

Figs 1, 2, 7, 11, 15, 17-19, 22, 23, 30-37, 57-60, 81, 95

**Type material.** HOLOTYPE, male, (WAM), Walyunga National Park, 31°46'S 116°01'E, Upper Swan, WA, 27 Feb. 1979, M. Gray, small sheet web under bark of *Eucalyptus wandoo* on banks of Swan River, WA. PARATYPES, allotype female, KS4483 (AM); 2 females, KS6085 and KS14963 (AM); 2 males, 4 females, KS3977 (AM) - all data as for holotype; 2 females, KS4482 (AM), Greenough River, Geraldton Highway, 17 km south of Geraldton, WA, 29°01'S 114°45'E, 21 Feb. 1979, M. Gray, small sheet webs under loose bark of eucalypt along river bank; 1 male, 91/1609 (WAM), East of Yorkkrakine Reserve, WA, 31°28'S 117°41'E, 8 Nov. 1988, D. Mitchell.

**Other material.** WESTERN AUSTRALIA, 1 juvenile, KS4633 (AM), Dandaragan, 30°40'S 115°42'E, 21 Oct. 1973, N. Poulter.

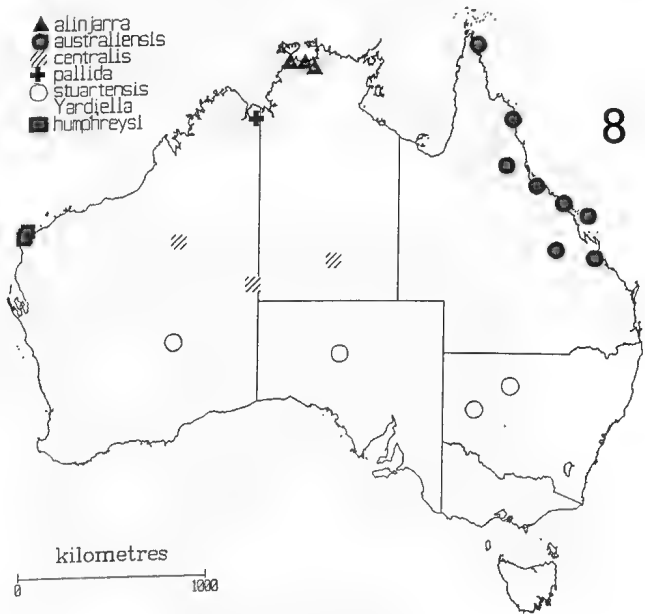
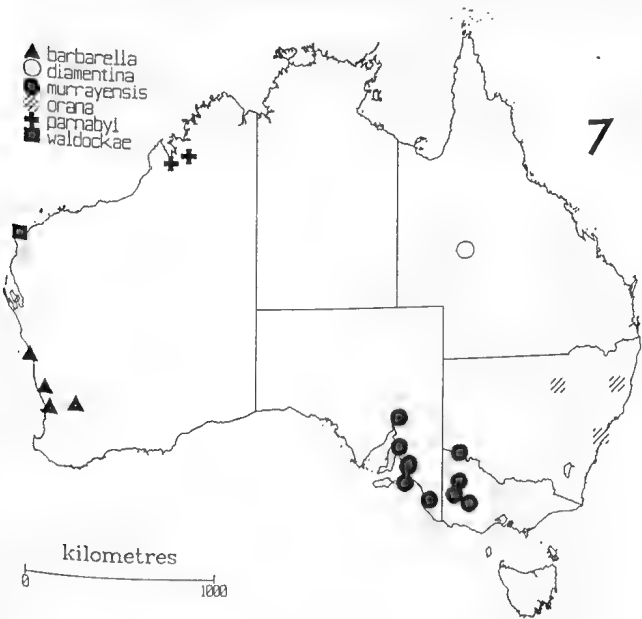
folded across subdistal embolus. Embolus strongly ventrally curved. Posterior sternal sigillae present. Calamistrum with short middle row of setae.

**Male.** Measurements. BL 3.1 (2.9-3.2), CL 1.34 (1.34-1.38), CW 1.08 (1.02-1.08), AL 1.71 (1.71-1.80), AW (0.96-1.10), CIL 0.32 (0.27-0.32), EGW 0.35 (0.35-0.36), MOAL 0.19 (0.19-0.20). Dorsal body pattern Fig. 37. Carapace mid-dorsal stripe strongly pigmented posteriorly, limbs of bifurcation short. Sternum with wide marginal pigment bands. CL : CW ratio 1 : 0.77. AER moderately, PER weakly procurved. Ratio AME : ALE : PLE : PME 11 : 14 : 10 : 10. Legs 1423.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.70	1.21	1.14	1.62
Patella	0.52	0.46	0.47	0.49
Tibia	1.78	1.08	0.98	1.41
Metatarsus	1.42	0.95	0.93	1.24
Tarsus	0.99	0.61	0.48	0.69
	6.41	4.41	4.00	5.45

TiB1L : CL ratio 1 : 0.75. Palpal tibia L/W ratio 1 : 0.60. Palpal organ. Distal tegulum excavated

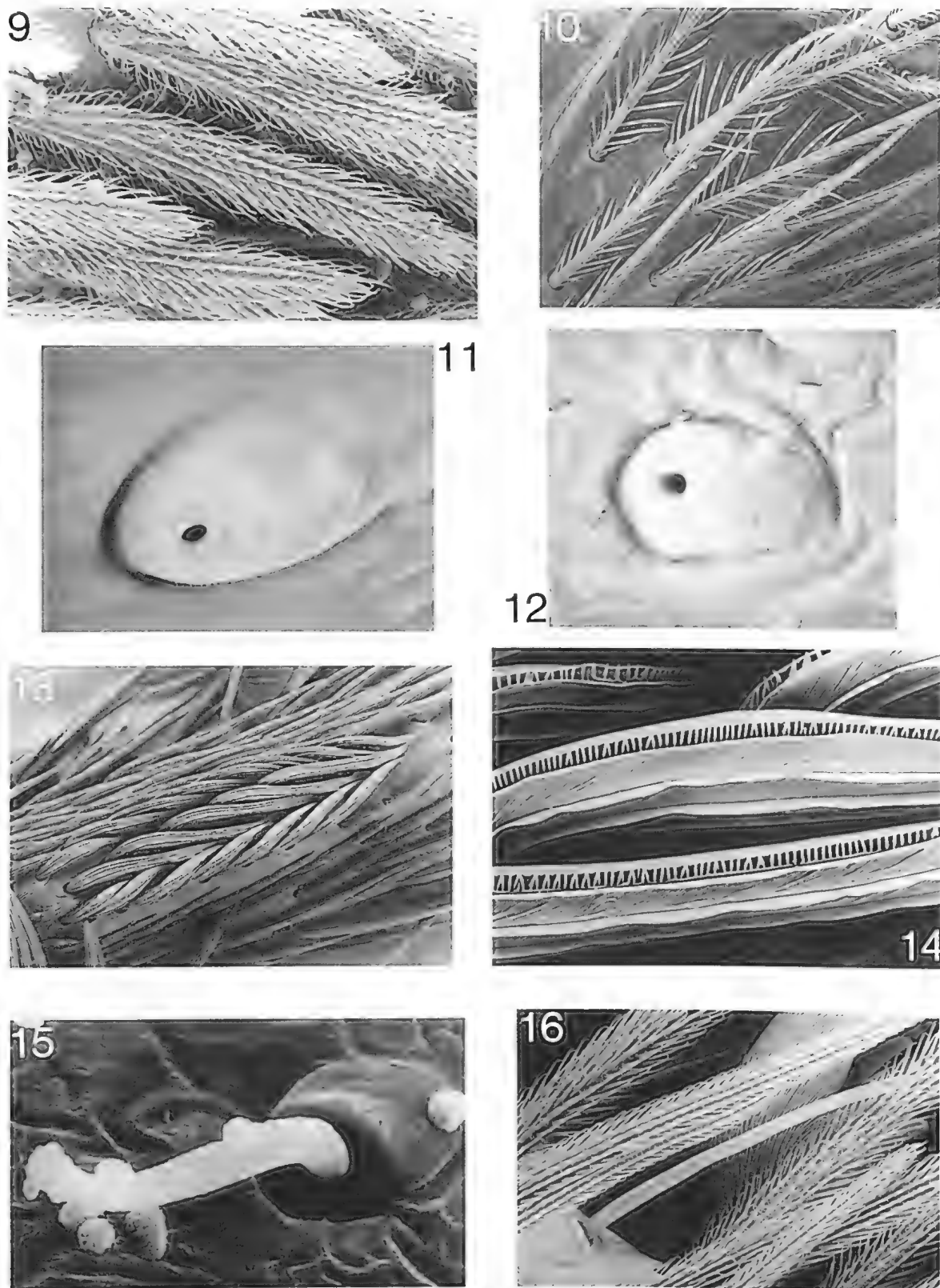
**Diagnosis.** Paraembolic lamina with rounded free end



Figs 7,8. Species distributions. 7, *Wandella* spp.; 8, *Wandella* spp. and *Yardiella humphreysi*.

prolaterally. Free end of paraembolic lamina bluntly rounded and strongly bent prolaterally across subdistal embolus. Embolus sinuous, strongly curved ventrally, flanged apically (Figs 30, 57-60).

*Female.* Similar to male. Measurements: BL 5.2 (3.1-5.2), CL 1.61 (1.48-1.62), CW 1.27 (1.14-1.30), AL 3.60 (1.90-3.86), AW 2.53 (1.40-2.57), CIL 0.32 (0.25-0.32), EGW 0.41 (0.36-0.41), MOAL 0.20 (0.19-0.22). Dorsal



**Figs 9-16.** *Wandella* and *Yardiella*. 9, ciliate hairs, *W. murrayensis*. 10, plumose hairs, *Y. humphreysi*. 11,12, tarsal organ: 11, *W. barbarella*; 12, *Y. humphreysi*. 13,14, *W. orana*: 13, calamistrum; 14, calamistrum setae. 15,16, sensilla: 15, tibia, metatarsus, *W. barbarella*; 16, apical tarsus, *W. orana*.



body pattern Figs 1, 37. Abdominal chevron pattern like male but often more diffuse. CL : CW ratio 1 : 0.79. Both eye rows moderately procurved. Ratio AME : ALE : PLE : PME 11 : 14 : 11 : 10. Posterior sternal sigillae present (Fig. 34). Legs 1423.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.60	1.14	1.07	1.52
Patella	0.48	0.43	0.44	0.44
Tibia	1.67	1.01	0.87	1.32
Metatarsus	1.33	0.89	0.86	1.16
Tarsus	0.93	0.57	0.45	0.65
	6.01	4.04	3.69	5.09

Tib1L : CL ratio 1 : 0.96. Middle row of calamistrum short, with 3-4 setae (Fig. 35). Lateral spermathecal lobes irregularly globose. Smaller medial lobes longer than wide, half to one third width of lateral lobes. Medial lobes separated by less than the width of a lateral lobe. Both lateral and medial lobes with moderately broad necks (Figs 33, 95).

**Etymology.** The specific name recognises Dr Barbara York Main and her remarkable and ongoing contribution to Australian arachnology.

**Biology.** These spiders build small, irregular sheet webs 3 to 6 cm across (Fig. 2) under loose bark of *Eucalyptus* spp., notably trees growing along watercourses. The webs have one to three tunnel entrances under, or at free edge of bark. Insect food remains and cast skins are embedded in the silk mesh.

**Distribution.** South Western Australia (Fig. 7).

### *Wandella parnabyi* n.sp.

Figs 7, 38-41, 103, 104

**Type material.** HOLOTYPE, male, KS30232 (AM), Fitzroy River crossing on Great Northern Highway, about 60 km south of Derby, WA, 17°40'S 123°35'E, 3 Mar. 1990, H. Parnaby, under loose bark of riverbank eucalypts. PARATYPES, allotype female, KS30233 (AM); 2 females, KS30234 and KS30235 (AM) - all with same data as holotype.

**Other material.** WESTERN AUSTRALIA, 1 juvenile, KS7529 (AM), near Barnett Cave, Napier Range, east of Derby, WA, 17°14'S 124°41'E, 20 June 1980, B. Duckworth, under rock on limestone outcrop.

**Diagnosis.** Similar to *W. barbarella*, but carapace narrower and paraembolic process longer, ending closer to embolus apex.

**Male.** Measurements: BL 2.1, CL 1.26, CW 0.86, AL 1.60, AW 0.97, CIW 0.22, EGW 0.38, MOAL 0.20. Dorsal body pattern Fig. 41. Abdomen with 6-7 well-defined chevrons separated by a central pale stripe. Carapace rather long, CL : CW ratio 1 : 0.68. AER straight, PER weakly procurved. Ratio AME : ALE : PLE : PME 14 : 15 : 13 : 11. Sternal sigillae

indistinct. Legs 1423.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.57	1.09	0.94	1.24
Patella	0.42	0.35	0.33	0.41
Tibia	1.69	1.04	0.83	1.19
Metatarsus	1.57	1.07	0.92	1.21
Tarsus	0.90	0.58	0.53	0.60
	6.15	4.13	3.55	4.65

Tib1L : CL ratio 1 : 0.75. Palpal tibia L/W ratio 1 : 0.62. Paraembolic process almost as long as embolus, aligned with dorsal tegulum margin, distal free margin curved above embolus (Fig. 39).

**Female.** Similar to male. Measurements: BL 1.8-2.3, CL 1.34 (1.09-1.34), CW 1.00 (0.75-1.00), AL 1.68 (1.55-2.62), AW 0.98 (0.98-1.49), CIW 0.25 (0.15-0.25), EGW 0.37 (0.30-0.37), MOAL 0.19 (0.17-0.19). Body pattern Fig. 38. CL : CW ratio 1 : 0.74. Clypeus broad, blunt. Eye rows procurved. Ratio AME : ALE : PLE : PME 12 : 14 : 12 : 10. Legs 1423.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.41	1.03	0.90	1.47
Patella	0.44	0.39	0.41	0.45
Tibia	1.37	0.83	0.67	1.07
Metatarsus	1.20	0.80	0.73	0.96
Tarsus	0.82	0.58	0.49	0.57
	5.24	3.63	3.20	4.52

Tib1L : CL ratio 1 : 0.96. Genitalia (Figs 103, 104) similar to *W. barbarella* but medial lobes separated by at least width of a lateral lobe.

**Etymology.** The species is named for its collector, Dr H. Parnaby, in recognition of his contribution to the Australian Museum spider collections.

**Distribution.** South-west Kimberley region (Fig. 7).

### *Wandella orana* n.sp.

Figs 3, 4, 5, 7, 13, 14, 16, 24-26, 42-51

**Type material.** HOLOTYPE, male, KS4659 (AM), Mount Colah, NSW, 33°40'S 151°07'E, 1 Feb. 1980, M.R. Gray, wandering on shed floor. PARATYPES, allotype female, KS13763 (AM), 15 Mar. 1982, small sheet web on beams in shed, other data as for holotype; 2 females, KS13960 (AM), 29 June 1988 and KS21501 (AM), 28 June 1988, other data as for allotype; 1 male, KS 37184 (AM), Site 39BR (NPWS/AM) on north-east facing slope above Kunderang Station Creek, 410 m, 30°48'S 152°06'E, 4 Feb.-9 Apr., M. Gray & G. Cassis, in pitfall trap.

**Other material.** NEW SOUTH WALES, 1 female, KS12841 (AM), Coombah Station Homestead, 30°43'S 148°20'E, Apr. 1982, M. Kotzman, in leaf litter.

**Diagnosis.** Posterior sternal sigillae present. Male palpal tibia longer than wide. Paraembolic lamina attached for most of length, closely associated with embolus and ending near its tip. Medial spermathecal lobes small,

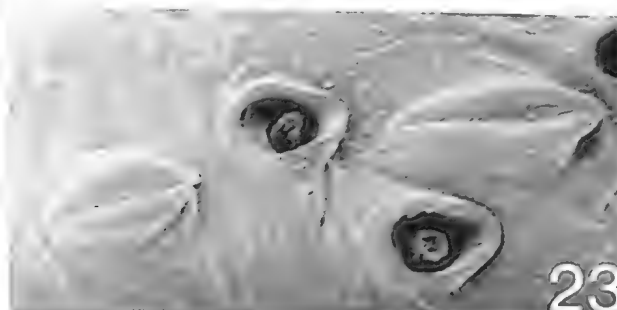
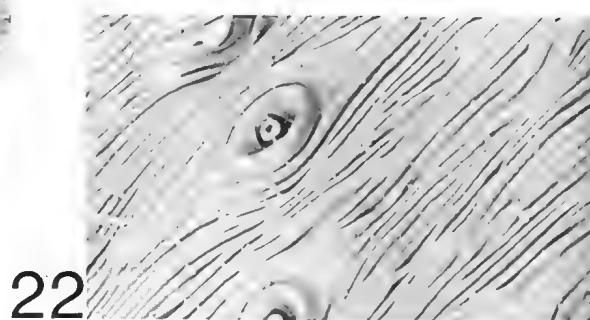
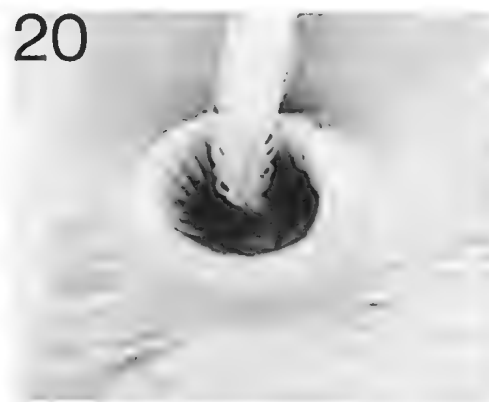
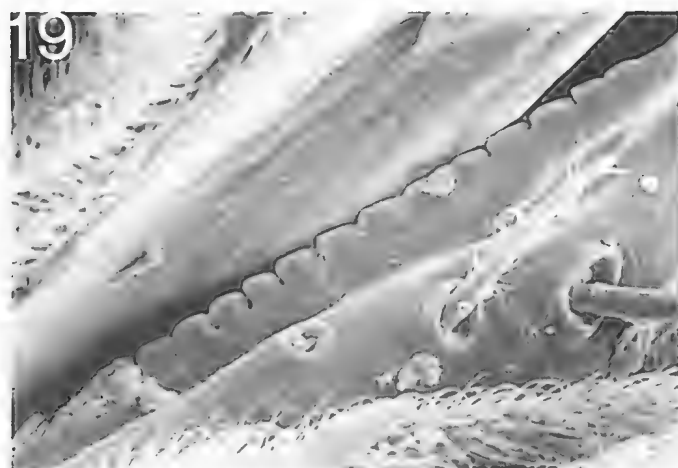
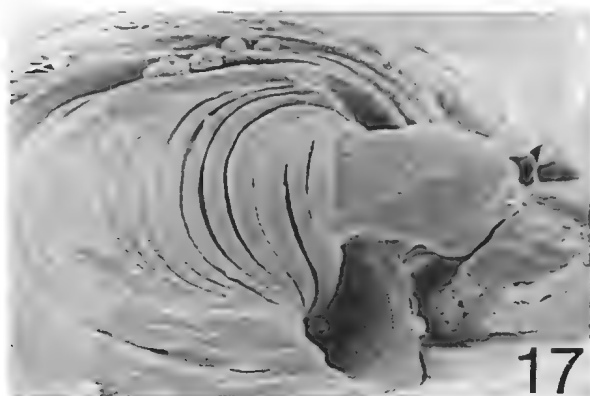


partly hidden behind lateral lobes.

*Male*. Measurements: BL 3.3, CL 1.38, CW 1.19, AL 1.86, AW 1.18, CIL 0.27, EGW 0.39, MOAL 0.23. Dorsal abdomen with indistinct pale patches flanking anterior mid-dorsal stripe; lateral chevrons narrow (Fig. 3). Sternum with weak, irregular marginal pigmentation. CL : CW ratio 1 : 0.86. Both eye rows weakly procurved. Ratio AME : ALE : PLE : PME 13 : 13 : 11 : 10. Legs

1423.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.89	1.38	1.16	1.48
Patella	0.44	0.43	0.40	0.43
Tibia	2.24	1.40	1.12	1.58
Metatarsus	1.90	1.22	1.14	1.50
Tarsus	1.18	0.70	0.61	0.78
	7.65	5.13	4.43	5.77



**Figs 17-23.** *Wandella* and *Yardiella*. 17-19,22,23, *Wandella barbarella*: 17, metatarsus/tarsus dorsal articulation; 18, distal chelicerae and maxillae; 19, maxillary serrula and chemosensitive hairs; 22, abdominal cuticle; 23, 'lyriform' organs on palpal tarsus. 20, *Yardiella humphreysi*, trichobothrium base. 21, *Wandella murrayensis*, tarsal claws.

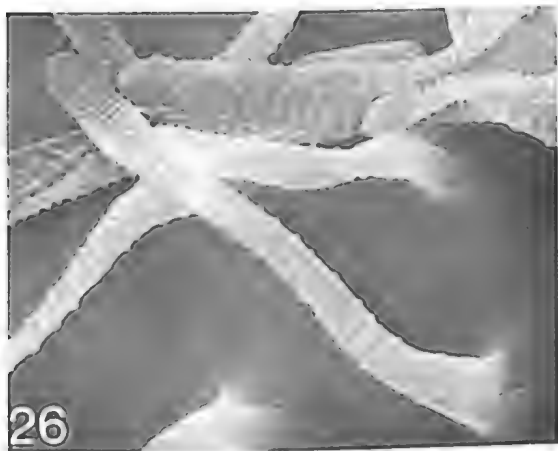
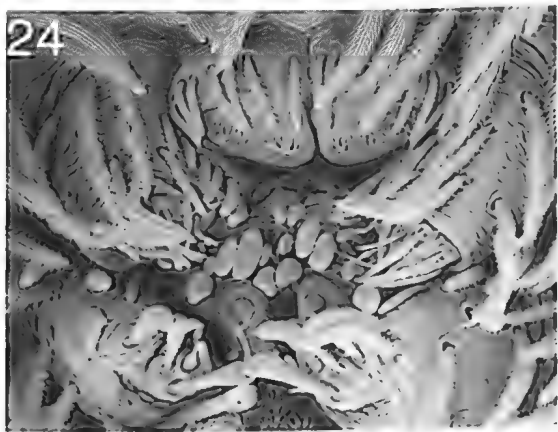
Tib1L:CL ratio 1:0.62. Palpal tibia L/W ratio 1:0.69. Paraembolic lamina attached to embolus for most of its length, truncate apex curved across the prolateral embolus to end close to its tip (Figs 42, 43).

*Female.* Similar to male. Measurements: BL 4.9 (4.9-5.2), CL 1.91 (1.84-2.09), CW 1.54 (1.51-1.75), AL 3.00 (3.00-3.13), AW 2.21 (2.15-2.21), CIL 0.36 (0.26-0.47), EGW 0.44 (0.44-0.49), MOAL 0.25 (0.24-0.25). Dorsal body pattern Fig. 46. Abdominal chevrons broader than in male. Posterior sternal sigillae present (Fig. 45). CL: CW ratio 1:0.81. AER slightly procurved, PER

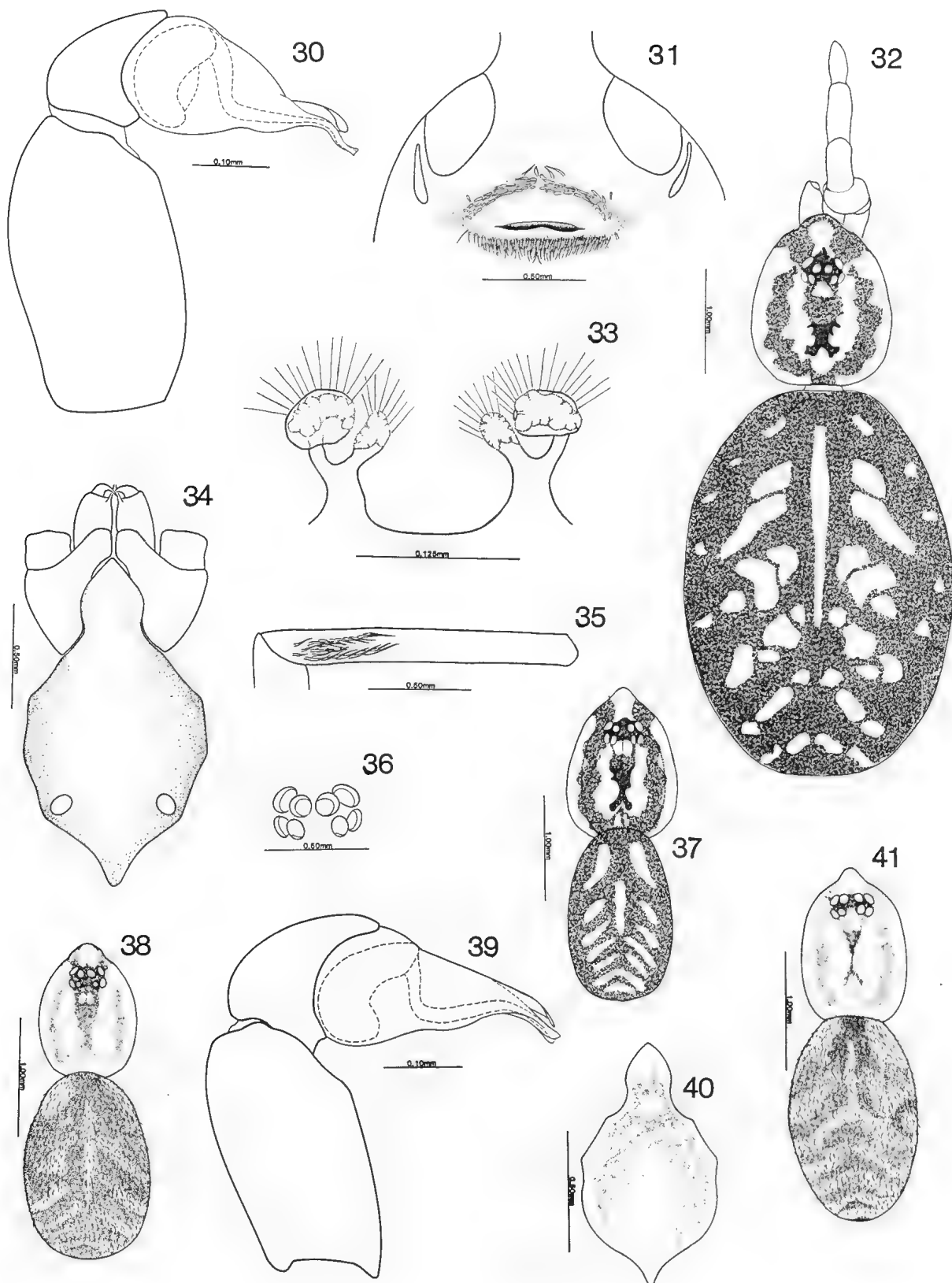
moderately procurved. Ratio AME:ALE:PLE:PME 13:19:14:11. Legs 1(42)3.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.60	1.50	1.07	1.52
Patella	0.48	0.57	0.44	0.44
Tibia	2.06	1.20	0.87	1.32
Metatarsus	1.33	1.18	0.86	1.16
Tarsus	1.22	0.80	0.37	0.82
	6.69	5.25	3.61	5.26

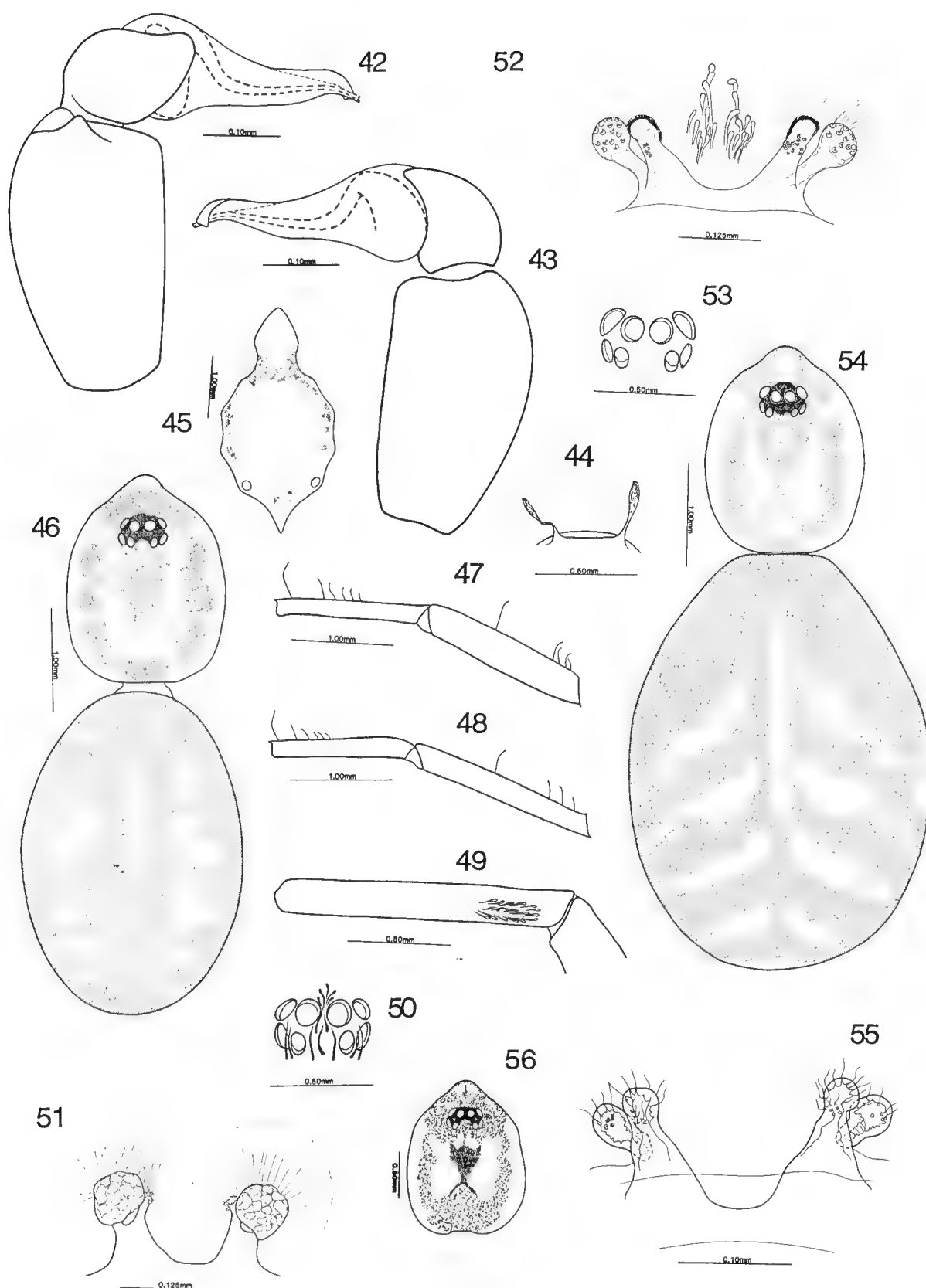
Tib1L:CL ratio 1:0.92. Spermathecae irregularly globose. Medial lobes 0.3-0.5 width of lateral lobes, sometimes partly obscured behind them. Medial



**Figs 24-29.** Spinnerets (females). 24-26, *Wandella orana*. 27-29, *W. murrayensis*. 24, spinnerets (note clavate setae). 25, cribellum. 26, cribellum spigots. 27, ALS spigots. 28, PMS spigots. 29, PLS spigots.



**Figs 30-41.** 30-37, *Wandella barbarella*: 30, male palp, prolateral; 31, epigynal region, groove open; 32, dorsal body, female; 33, internal genitalia; 34, labium, maxillae, sternum; 35, metatarsus 4, calamistrum; 36, eyes; 37, dorsal body, male. 38-41, *W. parnabyi*: 38, dorsal body, female; 39, male palp, prolateral; 40, labium, sternum; 41, dorsal body, male.



Figs 42-56. 42-51, *Wandella orana*: 42,43, male palp, 42, retrolateral, 43, prolateral; 44, posterior 'book lungs' and spiracles; 45, labium and sternum; 46, dorsal body, female; 47,48, tibial and metatarsal trichobothrium pattern, 47, leg 4, 48, leg 1; 49, metatarsus 4, calamistrum; 50, eyes; 51, internal genitalia. 52-56, *W. australiensis*: 52, internal genitalia; 53, eyes; 54, dorsal body, female; 55,6, syntype female; 55, internal genitalia, 56, dorsal carapace.

lobes separated by 0.5-1.5 times the width of a lateral lobe (Fig. 51).

**Etymology.** Orana is an Aboriginal word meaning welcome and refers to the unexpected discovery of this species in outer suburban Sydney, NSW.

**Distribution and biology.** This species is known primarily from a localised population, presumably introduced, associated with old farm buildings in outer suburban Sydney, central coastal New South Wales. No specimens have been found in bushland around Sydney. However, the recent collection of a male specimen from Kunderang Creek suggests that the real distribution of *W. orana* is in forest habitats of north-eastern NSW. A female specimen from north-central NSW is provisionally placed with this species. In their suburban habitat, these spiders make small, irregular sheet webs 3 to 8 cm across with two to four entrances (Fig. 5 shows a web built on a wooden beam inside a shed). These structures resemble smaller versions of the webs of desid spiders such as the black house spider, *Badumna insignis*. Insect food remains (flies, moths, beetles) and cast skins litter the silk sheets.

*Wandella australiensis* (L. Koch) n.comb.

Figs 8, 52-56

*Filistata australiensis* L. Koch, 1873: 451, pl. 35, fig. 4.  
*Pritha australiensis*.—Lehtinen, 1967: 260.—Davies, 1985: 64.

**Type material.** SYNTYPES, 4 females from Rockhampton, Qld, 23°22'S 150°32'E, in ZMH Museum Godeffroyi No. 8098, examined. (Additional ?type material from MNHN and NHMW noted by Lehtinen (1967), not seen).

**Other material.** QUEENSLAND, 1 female, S679 (QM), Peak Downs Station, south-east of Clermont, 22°56'S 148°05'E, 30 Nov. 1973, R.J. McKay, in 'silk lined burrow'; 1 female, KS7353 (AM), Mount Dryander (lower slopes), north of Proserpine, 20°15'S 148°32'E, Apr. 1975, M. Gray & C. Horseman, dry vine forest (A.M. rainforest survey Site 12), under bark; 1 female, S6752 (QM), Bushy Island, 20°57'S 150°05'E, June 1975, D. Gleason; 1 female, S6753 (QM), Lansdown Station, Woodstock, near Townsville, 19°16'S 146°49'E, 30 Oct. 1975, A. Brown; 1 female, S6757 (QM), Douglas Island, Great Barrier Reef, 11°14'S 142°59'E, 21 Dec. 1979, R. Buckley; 1 female, S6758 (QM), Forty Mile Scrub, 18°05'S 144°53'E, 11 Apr. 1978, V.E. Davies, in web under bark; 1 female (MNHN, bottle 477), Cooktown, 15°28'S 145°15'E.

**Diagnosis.** Similar to *W. orana*, but spermathecal lobes much more widely separated. (Male unknown).

**Description of female** (Peak Downs). Measurements: BL 5.9, CL 1.91, CW 1.54, AL 4.0, AW 2.88, CIL 0.36, EGW 0.47, MOAL 0.25. (Rockhampton holotype female

CL 1.66, CW 1.32). Dorsal body pattern Figs 54, 56. Carapace with mid-dorsal stripe deeply bifurcate posteriorly. Sternum strongly pigmented marginally. CL: CW ratio 1:0.79. Eye rows procurved. AME: ALE: PLE: PME 10:14:13:11. Posterior sternal sigillae present. Legs 1423.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	2.03	1.49	1.29	1.95
Patella	0.66	0.61	0.56	0.63
Tibia	2.07	1.21	1.01	1.55
Metatarsus	1.74	1.25	1.12	1.48
Tarsus	1.21	0.76	0.71	0.85
	7.71	5.34	4.69	6.46

Tib1L: CL ratio 1:0.92. Spermathecal lobes diverge laterally, widely separated. Medial lobes 0.5-1 times width of lateral lobes, and separated by 3-4 widths of a lateral lobe (Figs 52, 55).

**Biology.** This species has been recorded in habitats ranging from rainforest to woodland. Until males are available it is difficult to be certain that only a single species is involved. It is interesting to note that a female from the drier part of this range (Peak Downs) was taken from a 'silk lined burrow'.

**Distribution.** North-central east Queensland (Fig. 8).

*Wandella alinjarra* n.sp.

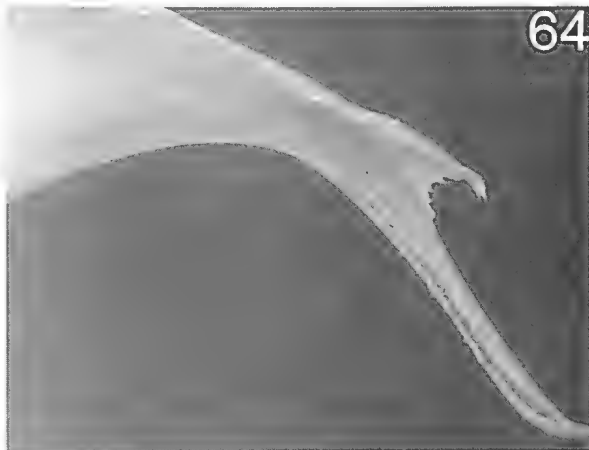
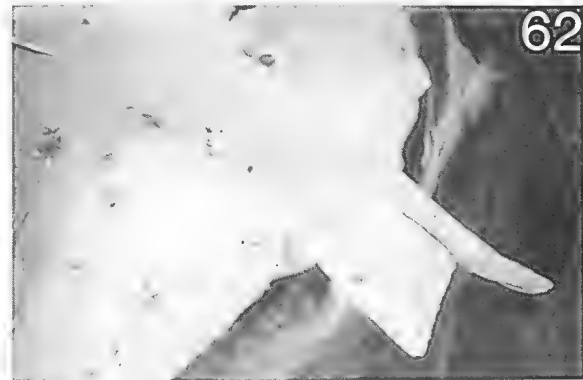
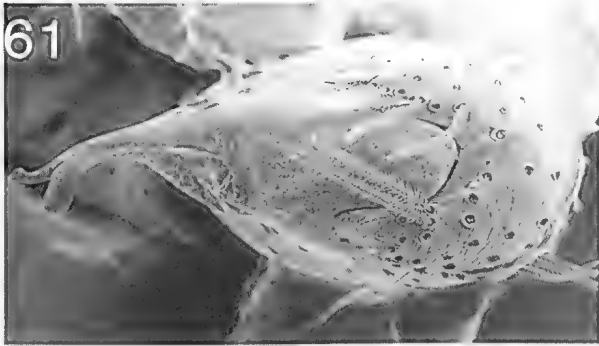
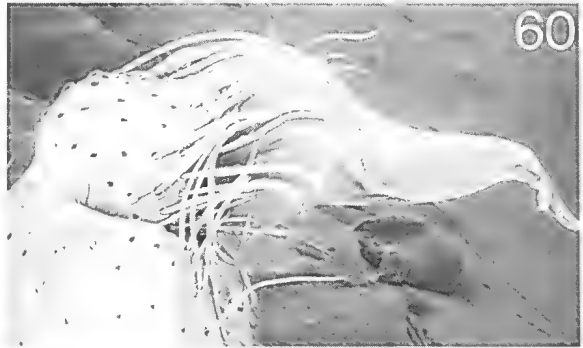
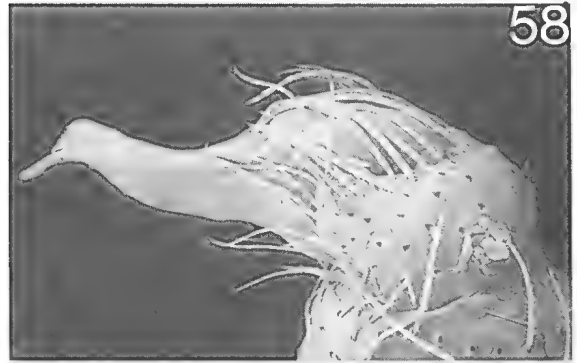
Figs 8, 64, 71-77

**Type material.** HOLOTYPE, male, S681 (QM), Lee Point, Darwin, Northern Territory (NT), 12°21'S 131°54'E, 7 June 1979, G.B. Monteith, in rainforest litter (QM berlesate no.92). PARATYPES, allotype female, S681 (QM), data as for holotype; 1 female, KS32145, data as for holotype; 2 females, (MV), Red Lily Billabong, Kapalga, Kakadu National Park, NT, 1 July 1987, M.S. Harvey & A.L.Yen; 1 female, Alligator River, Mount Elliot National Park, NT, 19°25'S 147°01'E.

**Other material.** NORTHERN TERRITORY, 3 juveniles, S6754 (QM), South Alligator Inn, Kakadu National Park, 12°40'S 132°30'E, Nov. 1979, R. Raven, under logs.

**Diagnosis.** Small spiders (CL about 1 mm). Male palpal tibia very short. Paraembolic process narrow and crest-like, anterior margin ragged. Clypeus only slightly longer than median ocular area. PME-PME about diameter of a PME.

**Male.** Measurements: BL 2.5, CL 1.08, CW 0.85, AL 1.38, AW 0.96, CIL 0.20, EGW 0.35, MOAL 0.18. Non-pigmented postocular area smaller than in other species. Frontal area of abdomen without obvious pale markings. Sternum margins moderately pigmented. CL: CW ratio 1:0.79. Median ocular area about as long as clypeus. AER and PER weakly procurved. Ratio AME: ALE: PLE: PME 11:15:11:10. PME-PME equal to or less than diameter of a PME. Sternal sigillae not visible. Legs 1423.



**Figs 57-64.** Male palps. 57-60, *Wandella barbarella*: 57, retrolateral; 58, prolateral; 59, dorsal; 60, embolus and paraembolic process, dorsal. 61-63, *W. murrayensis*: 61, retrolateral; 62, prolateral; 63, embolus and paraembolic process (tegular flange at left), dorsal. 64, *W. alinjarra*, embolus and paraembolic process, dorsal.



	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.58	1.22	0.96	1.30
Patella	0.46	0.36	0.29	0.36
Tibia	1.80	1.13	0.87	1.35
Metatarsus	1.51	1.06	0.88	1.23
Tarsus	0.96	0.50	0.59	0.77
	6.31	4.27	3.59	5.01

Tib1L:CL ratio 1:0.60. Palpal tibia very short, L/W ratio 1:0.95, about as long as patella. Paraembolic process narrow, prolaterally curved distal part tapering to a point above the ragged distal margin. Embolus ventrally curved with slight dorsal reflexion at apex (Figs 64, 74, 75).

*Female*. Similar to male. Measurements: BL 3.9 (2.5), CL 1.12 (0.96), CW 0.83 (0.78), AL 2.78 (2.50), AW 1.73 (1.61), CIL 0.20 (0.15), EGW 0.33 (0.29), MOAL 0.17 (0.16). Dorsal body pattern Fig. 77. CL: CW ratio 1:0.74. AER straight to slightly procurved, PER weakly procurved. Ratio AME: ALE: PLE: PME 8:11:9:8. Legs (1)423 (legs 1 tibiae, metatarsi and tarsi missing).

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.20	0.90	0.78	1.10
Patella	0.38	0.32	0.33	0.36
Tibia	—	0.79	0.64	1.08
Metatarsus	—	0.69	0.64	0.88
Tarsus	—	0.50	0.40	0.58
	—	3.20	2.79	4.02

Calamistrum very short, 4-5 hairs in outer rows, 3 in middle row (Fig. 72). Spermathecae globose, medial lobes about 0.75 times width of lateral lobes, and separated by more than the width of a lateral lobe. All lobes with well-defined necks (Fig. 73).

**Etymology.** Alinjarra is an Aboriginal word meaning north and refers to the northern Australian distribution of this species.

**Distribution.** Northern Territory (Fig. 8)

### *Wandella murrayensis* n.sp.

Figs 7, 9, 21, 27-29, 61-63, 82-86, 96, 97

**Type material.** HOLOTYPE, male, ARA5311(11) (SAM), Felixstowe, Adelaide, SA, on bank of Torrens River at junction with Forth Creek, 35°46'S 138°36'E, 7 Sept. 1985, D. Hirst, under *Eucalyptus* bark. PARATYPES, allotype female, data as for holotype; 1 male, 3 females, (SAM), Torrens River, Adelaide, SA, between Zoo and Hackney Bridge, 35°46'S 138°36'E, 8 Jan. 1986, D. Hirst, under *Eucalyptus* bark; 1 male, (SAM), Heywood Park, Adelaide, SA, 5 Apr. 1975, R.V. Southcott, under bark of *E. camaldulensis*; 2 males, 1 female, KS35718 (AM), Parra Wirra National Park, South Para River, SA, 34°42'S 138°50'E, 21 May 1983, D. Hirst, under bark; 1 female, (SAM), Marcollat, 40 km east-north-east of Kingston South-East, SA, 36°45'S 140°10'E, Sept. 1974; 1 male, 1 female, Melrose, SA, 32°05'S 138°11'E, A.M. Lea; 1 male, 1 female, (SAM), Blair Athol, Adelaide, SA, 29 Apr. 1979, D. Hirst, in old brick incinerator; 1 female, KS12619 (AM),

24 km south of Redhill, Princes Highway, SA, 33°44'S 138°13'E, 8 Aug. 1980, M. Harvey, under bark of *E. camaldulensis*. 1 male, 1 female, (SAM), Kulkine Forest, Murray River, Vic., south-east of Red Cliffs, 34°18'S 142°??'E, 7 Oct. 1979, D. Hirst, under bark on river bank; 2 males, 2 females, (SAM), 1 km south-west of Deep Lead, Vic., 37°01'S 142°43'E, 20 June 1989, D. Hirst, under eucalypt bark; 3 females, (MV), 5 km west of Mildura, Vic., 34°10'S 142°06'E, 21 Sept. 1985, M.S. Harvey, B.J. Scott, L.A. Hoare, under bark of *E. camaldulensis*; 1 female, KS29235 (AM), Merbein, Vic., 34°10'S 142°04'E, W.J. Webster; 2 females, KS12838-9 (AM), Horseshoe Bend, Little Desert National Park, Vic., 36°30'S 141°45'E, 6 July 1982, M.S. Harvey & B. Roberts, under *E. camaldulensis* bark; 1 female, KS12840 (AM), Lake Alpacutya National Park, 15 km west-north-west of Yaaheet, Vic., 35°46'S 142°03'E, 3 July 1982, M.S. Harvey & B. Roberts.

**Diagnosis.** Similar to *W. barbarella* but differs as follows: male with carapace only a little shorter than tibia 1. Male palp with broad tegulum, distal area flanged prolaterally. Paraembolic lamina wide, free end rounded. Palpal tibia clearly longer than wide.

*Male*. Measurements: BL 3.1 (2.9-3.5), CL 1.46 (1.36-1.51), CW 1.11 (1.00-1.23), AL 1.62 (1.62-1.86), AW 0.92 (0.90-1.10), CIL 0.28 (0.26-0.36), EGW 0.35 (0.32-0.37), MOAL 0.22 (0.18-0.22). Colour pattern like *W. barbarella*, but not as heavily pigmented at foveal area. Margins of sternum strongly pigmented. CL: CW ratio 1:0.76. AER and PER both procurved. Ratio AME: ALE: PLE: PME 12:13:10:9. Posterior sternal sigillae indistinct. Legs 1423, short relative to CL.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.57	1.07	0.90	1.26
Patella	0.44	0.41	0.38	0.47
Tibia	1.67	0.98	0.89	1.21
Metatarsus	1.49	1.00	0.89	1.23
Tarsus	0.92	0.51	0.48	0.55
	6.09	3.97	3.46	4.72

Tib1L:CL ratio 1:0.87. Palpal tibia L/W ratio 1:0.61. Tegulum broad with a prolateral flange-like distal margin curving strongly round to embolus; wide lamina of paraembolic process curved prolaterally across subdistal embolus (Figs 61-63, 82-84).

*Female*. Similar to male. Measurements: BL 5.0 (3.8-5.2), CL 1.88 (1.61-1.96), CW 1.45 (1.29-1.59), AL 3.10 (2.22-3.10), AW 2.07 (1.24-2.07), CIL 0.37 (0.28-0.43), EGW 0.44 (0.39-0.45), MOAL 0.22 (0.21-0.23). Dorsal body pattern Fig. 85. Ventral abdominal stripe partially longitudinally divided by paler central stripe. Clypeus partially divided by thin pigment band. CL: CW ratio 1:0.77. Ratio AME: ALE: PLE: PME 15:25:15:12. Legs 1423.

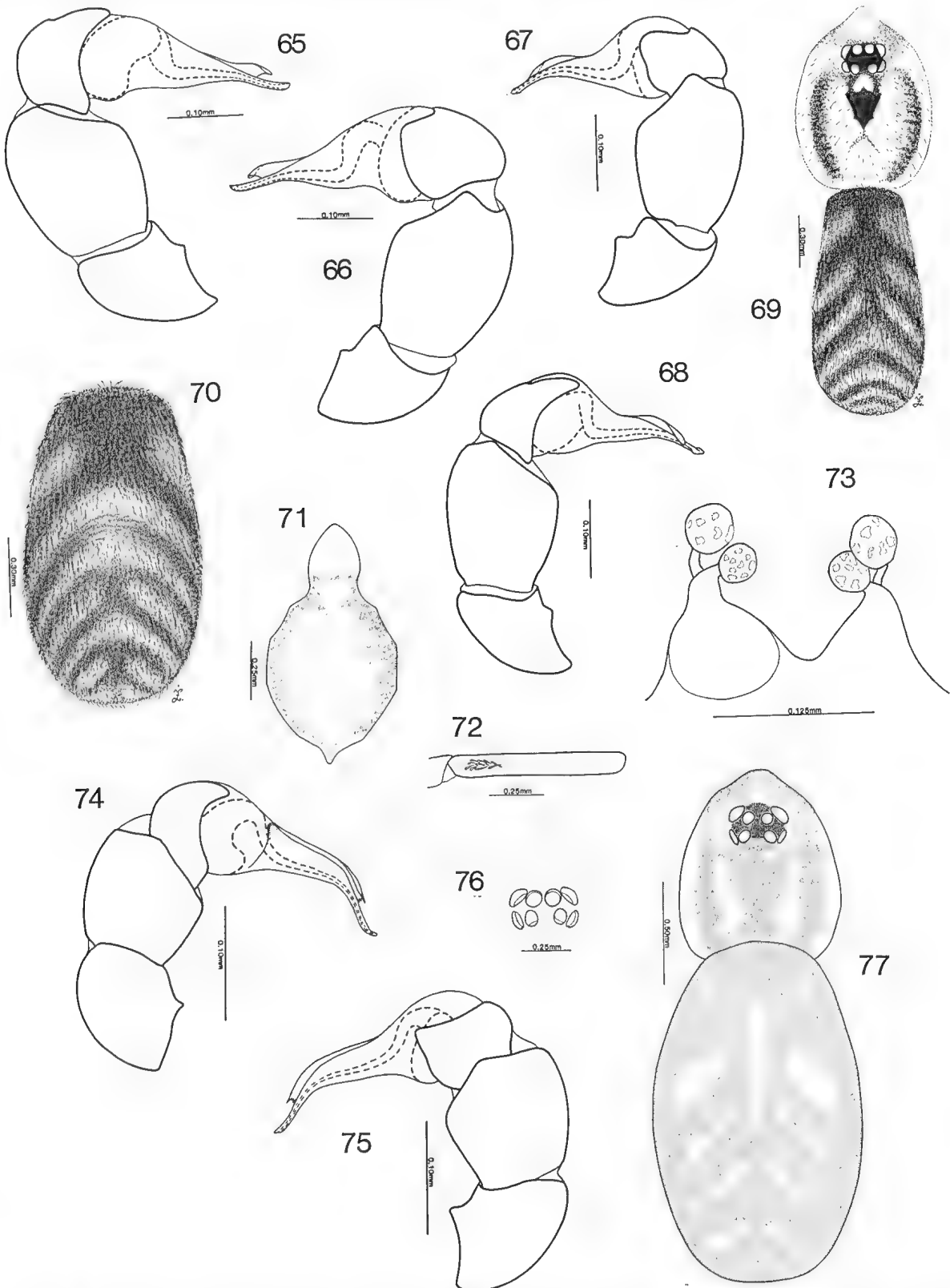
	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.74	1.28	1.21	1.68
Patella	0.61	0.62	0.56	0.68
Tibia	1.72	1.03	0.85	1.46
Metatarsus	1.60	1.04	0.96	1.32
Tarsus	1.07	0.67	0.57	0.73
	6.74	4.64	4.15	5.87

Tib1L:CL ratio 1:0.91. Lateral spermathecal lobes



slightly larger than medial lobes, the latter separated by more than the width of a lateral lobe. Neck of lateral lobes narrow, of medial lobes broad. (Figs 96, 97).

**Etymology.** The specific name refers to the Murray River district, an important part of the distribution of this species.



**Figs 65-77.** 65-70, *Wandella stuartensis*: 65-68, male palp, 65,66, Tintinalogy, NSW, 67,68, Mabel Creek, SA, 65,68, prolateral, 66,67 retrolateral; 69,70, dorsal body, female, 69, Tintinalogy, NSW, 70, Mabel Creek, SA. 71-77, *W. alinjarra*: 71, labium and sternum; 72, metatarsus 4, calamistrum; 73, internal genitalia; 74,75, male palp, 74, prolateral, 75, retrolateral; 76, eyes; 77, dorsal body, female.

**Distribution.** South-eastern Australia (Fig. 7).

***Wandella stuartensis* n.sp.**

Figs 8, 65-70, 80

**Type material.** HOLOTYPE, male, ARA5311(2) (SAM), Lagoon Waterhole, Mabel Creek Station, SA, 28°56'S 134°19'E, 26 Oct. 1984, P. Greenslade, in pitfall trap. PARATYPES, 1 male, ARA5311(2) (SAM), Tintinology Station, NSW, about 50 km north-east of Menindee on Darling River bank, 32°05'S 142°59'E, 6 Apr. 1981, D. Hirst; 1 male, KS35718 (AM), 7-8 km west-north-west of Point Salvation, WA, 28°12'S 123°36'E, 12 Oct. 1990, E. Pianka; 2 males, 91/1607-8 (WAM), Red Sands, WA, 28°12'S 123°35'E, 6 Nov. 1989, E. Pianka.

**Other material.** NEW SOUTH WALES, 1 juvenile, KS4634 (AM), Pulpulla Station, 30°45'S 145°15'E, 6 Oct. 1968, M. Gray.

**Diagnosis.** Legs long in male, tibia 1 twice as long as carapace. Male palp similar to *W. murrayensis*, but tibia shorter. Abdomen with strongly banded dorsal pattern. (Female unknown).

**Male.** Measurements: BL 2.3 (2.2), CL 1.00 (0.89), CW 0.83 (0.72), AL 1.15 (1.34), AW 0.78 (0.73), CIL

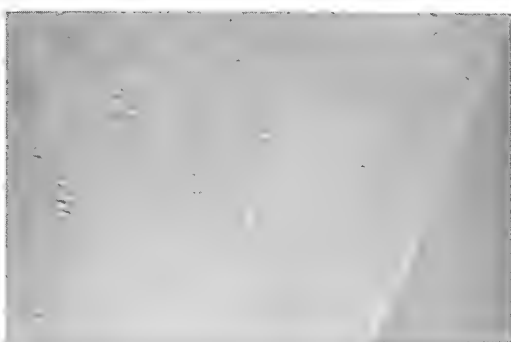
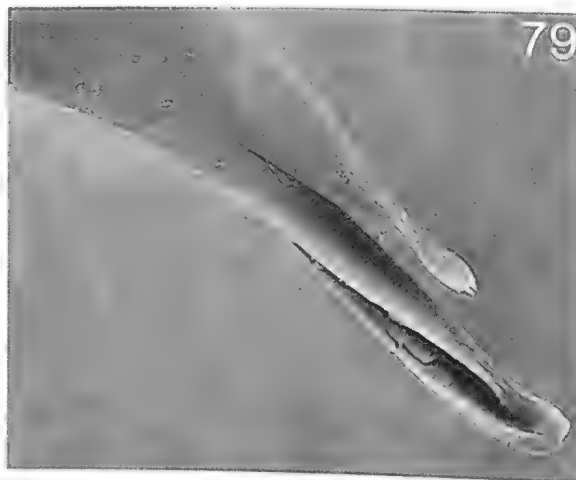
0.25 (0.23), EGW 0.29 (0.31), MOAL 0.18 (0.22). Dorsal body pattern Figs 69, 70. Pre-foveal part of carapace mid-dorsal stripe as dark as eye region. Submarginal bands weakly scalloped. Anterior abdominal chevrons separated by dark stripe, posterior chevrons joined, giving a banded appearance. Sternum with moderately pigmented lateral margins. CL : CW ratio 1 : 0.83. Both eye rows procurved. Ratio AME : ALE : PLE : PME 12 : 13 : 10 : 8. Sternal sigillae indistinct. Legs 1423, long.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.80	1.15	1.00	1.39
Patella	0.45	0.40	0.43	0.47
Tibia	2.18	1.23	0.96	1.40
Metatarsus	1.89	1.14	1.01	1.37
Tarsus	1.08	0.59	0.54	0.68
	7.40	4.51	3.94	5.31

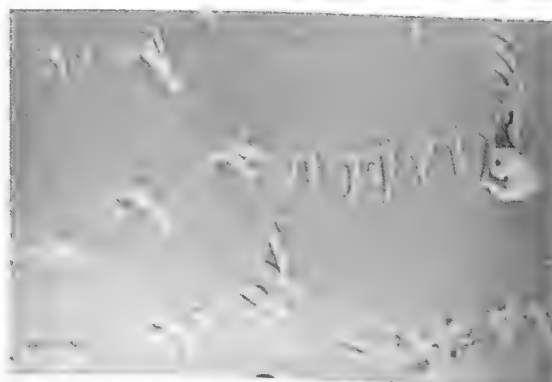
Tib1L : CL ratio 1 : 0.45. Palpal tibia short (Fig. 65), L/W ratio 1 : 0.80. Palpal organ (Figs 65-68) similar to *W. murrayensis*. Paraembolic lamina rounded apically, curved across prolateral side of subdistal embolus. Embolus only slightly ventrally curved, apex bent retrolaterally.

**Etymology.** The specific name refers to the Stuart Range near the type locality of this species.

**Distribution.** Southern inland Australia (Fig. 8).

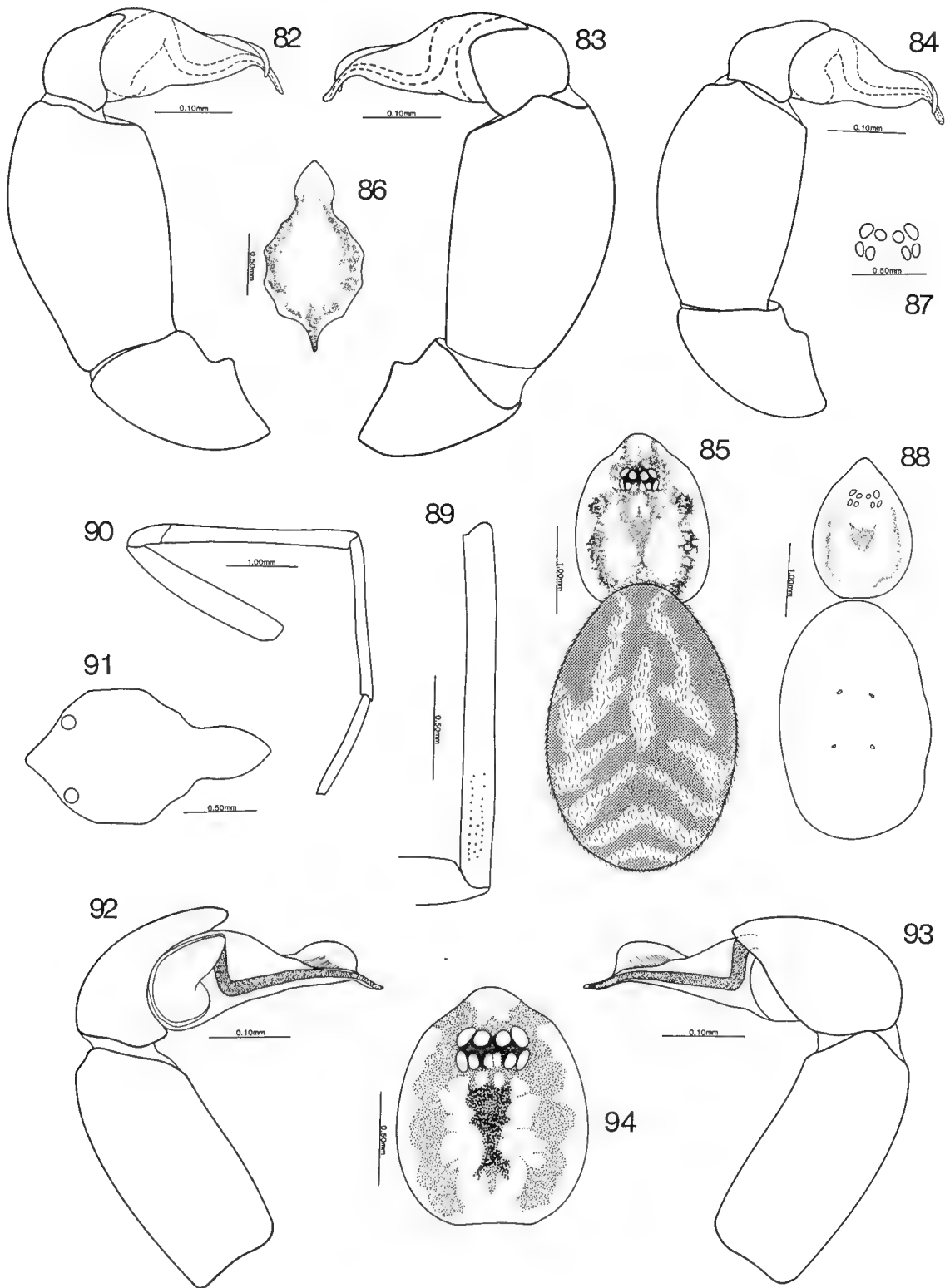


80



81

**Figs 78-81.** Male palp. 78,79, *Wandella pallida*, embolus and paraembolic process: 78, retrolateral; 79, prolateral. 80,81, comb-like tooth arrays on paraembolic process: 80, *W. stuartensis*, retrolateral; 81, *W. barbarella*, prolateral.



**Figs 82-94.** 82-86, *Wandella murrayensis*: 82-84, male palp, 82, prolateral (Adelaide), 83, retrolateral (Adelaide), 84, prolateral (Melrose); 85, dorsal body, female; 86, labium and sternum. 87-91, *W. diamantina*: 87, eyes; 88, dorsal body, female; 89, calamistrum setal pattern; 90, leg 1; 91, labium, sternum. 92-94, *W. waldockae*: 92, 93, male palp, 92, prolateral, 93, retrolateral; 94, dorsal carapace, male.

*Wandella diamentina* n.sp.

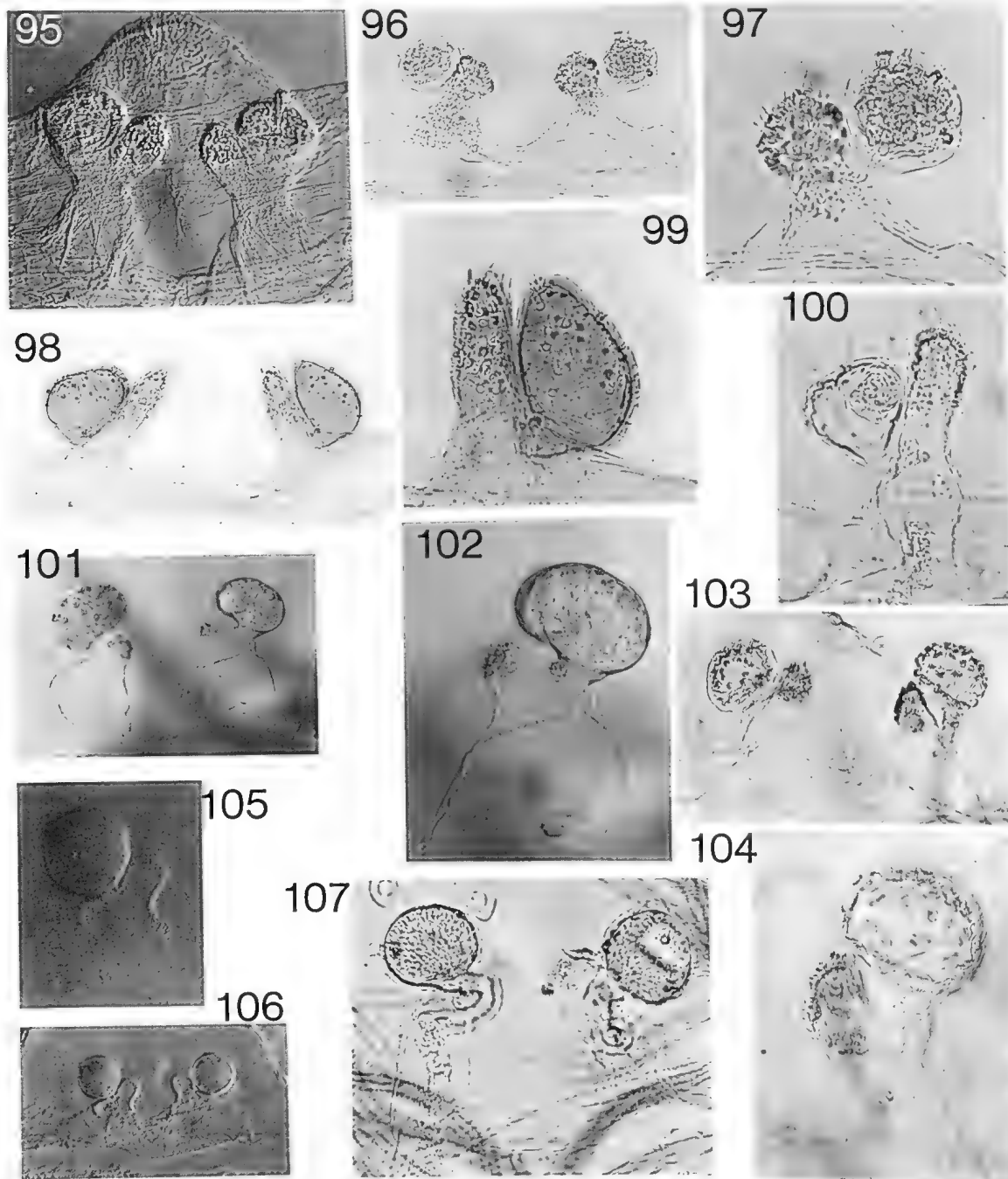
Figs 7, 87-91, 105, 106

**Type material.** HOLOTYPE, female, S6751 (QM), Wyrallah Station, south-west of Winton, Qld, 22°46'S 142°22'E, 15 July 1981, A. Rozefelds, under rock. PARATYPES, 2 juveniles, data as for holotype.

**Diagnosis.** Legs long, female tibia 1 almost 1.5 times as long as carapace. Body of preserved specimens very

pale. Lateral receptacula without secretory glands. (Male unknown).

**Female.** Measurements: BL 4.68, CL 1.76, CW 1.26, AL 2.98, AW 1.89, CIL 0.32, EGW 0.41, MOAL 0.19. Body pigment/patterning vestigial (in preservative), cephalothorax and legs pale amber, carapace with very faint standard pattern, abdomen cream coloured (Fig. 88). Carapace long ovoid, CL : CW ratio 1 : 0.72. Both eye rows procurved. Ratio AME : ALE : PLE : PME 8 : 11 : 9 : 7. Posterior sternal sigillae present (Fig. 91). Legs 1423, long.



Figs 95-107. Internal genitalia. 95, *Wandella barbarella*. 96,97, *W. murrayensis*. 98-100, *W. centralis*: 98,99, Canning Stock Route; 100, Alice Springs. 101,102, *W. pallida*. 103,104, *W. parnabyi*. 105,106, *W. diamentina*. 107, *Yardiella humphreysi*.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	2.21	1.44	1.34	1.87
Patella	0.53	0.47	0.49	0.61
Tibia	2.54	1.40	1.10	1.79
Metatarsus	2.11	1.15	1.17	1.62
Tarsus	1.36	0.74	0.71	0.81
	8.75	5.20	4.81	6.70

Tib1L : CL ratio 1 : 0.69. Calamistrum lateral hair rows long, with 12-13 setae (Fig. 89). Palpal tarsus long, slender. Lateral spermathecal lobes large and smoothly spherical, without secretory glands. Medial lobes glandular and small, one third width of lateral lobes, and separated by two thirds the width of a lateral lobe (Figs 105, 106).

**Etymology.** The species name refers to the Diamantina River which runs near the type locality.

**Distribution.** Known only from the type locality (Fig. 7).

*Wandella waldockae* n.sp.

Figs 7, 92-94

**Type material.** HOLOTYPE, male, 90/1909 (WAM), near Cave C118, North West Cape, WA, 22°09'S 113°59'E, 12 Sept. 1989, B. Jones, W.F. Humphreys & A. Humphreys (ref. 278), from surface pitfall trap near cave entrance.

**Diagnosis.** Small spiders. Male palp with erect, 'sail-like' paraembolic lamina above embolus. Palpal tibia short (female unknown).

**Male.** BL 2.3, CL 1.00, CW 0.76, AL 1.31, AW 0.64, CIW 0.17, EGW 0.29, MOAL 0.17. Carapace Fig. 94 (abdomen damaged but colour pattern as for genus). CL : CW ratio 1 : 0.76. Eye rows weakly procurved. AME : ALE : PME : PLE 8 : 11 : 7 : 8. Sternal sigillae indistinct or absent. Legs 1423.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.46	0.95	0.75	1.09
Patella	0.34	0.31	0.31	0.36
Tibia	1.62	0.88	0.69	1.09
Metatarsus	1.36	0.87	0.71	1.05
Tarsus	0.81	0.44	0.43	0.52
	5.59	3.45	2.89	4.11

Tib1L : CL 1 : 0.62. Palpal tibia L/W ratio 1 : 0.44. Palpal organ with distinctive, membranous paraembolic process, held erect above embolus (Fig. 92, 93).

**Etymology.** The species is named after Ms J. Waldock, Technical Officer in Arachnology at the Western Australian Museum.

**Distribution.** Type locality only (Fig. 7).

*Wandella centralis* n.sp.

Figs 8, 98-100, 108-112

**Type material.** HOLOTYPE, male (CAS), Alice Springs, NT, 23°42'S 133°52'E, 29 Oct. 1962, E.S. Ross & D. Cavagnaro. PARATYPES, allotype female (CAS), data as for holotype; 3 females (CAS), data as for holotype; 2 females, KS32146 (AM), data as for holotype. 1 female, 88/47 (WAM), Canning Stock Route near Well 29, WA, 22°34'S 123°53'E, 3 Aug. 1987, A.E. De Jong, under bark of 'oak' (?*Casuarina*); 1 female, 90/1917 (WAM), Giles Creek Crossing, WA, 25°03'S 128°40'E, 15 Jan. 1990, M.S. Harvey & T.F. Houston.

**Diagnosis.** Male palpal tibia long. Paraembolic lamina as long as embolus. Female genitalia with elongate medial lobes.

**Male.** Measurements. CL 1.59, CW 1.27, AL 0.82, AW 1.71, AL 1.13, CIW 0.30, EGW 0.37, MOAL 0.22. Dorsal body pattern Figs 103, 104, abdomen with 4-5 chevrons. CL : CW ratio 1 : 0.80. Eye rows weakly procurved. Ratio AME : ALE : PLE : PME 15 : 16 : 12 : 10. Posterior sternal sigillae present, small. Legs 1423.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	1.84	1.24	1.03	1.75
Patella	0.45	0.33	0.39	0.48
Tibia	1.85	1.22	1.02	1.82
Metatarsus	1.61	1.21	1.02	1.25
Tarsus	1.03	0.58	0.53	0.71
	6.78	4.58	3.99	6.01

Tib1L : CL ratio 1 : 0.86. Palpal tibia long, L/W ratio 1 : 0.50. Palpal organ (Figs 108, 109) with long, crest-like paraembolic process, as long as embolus.

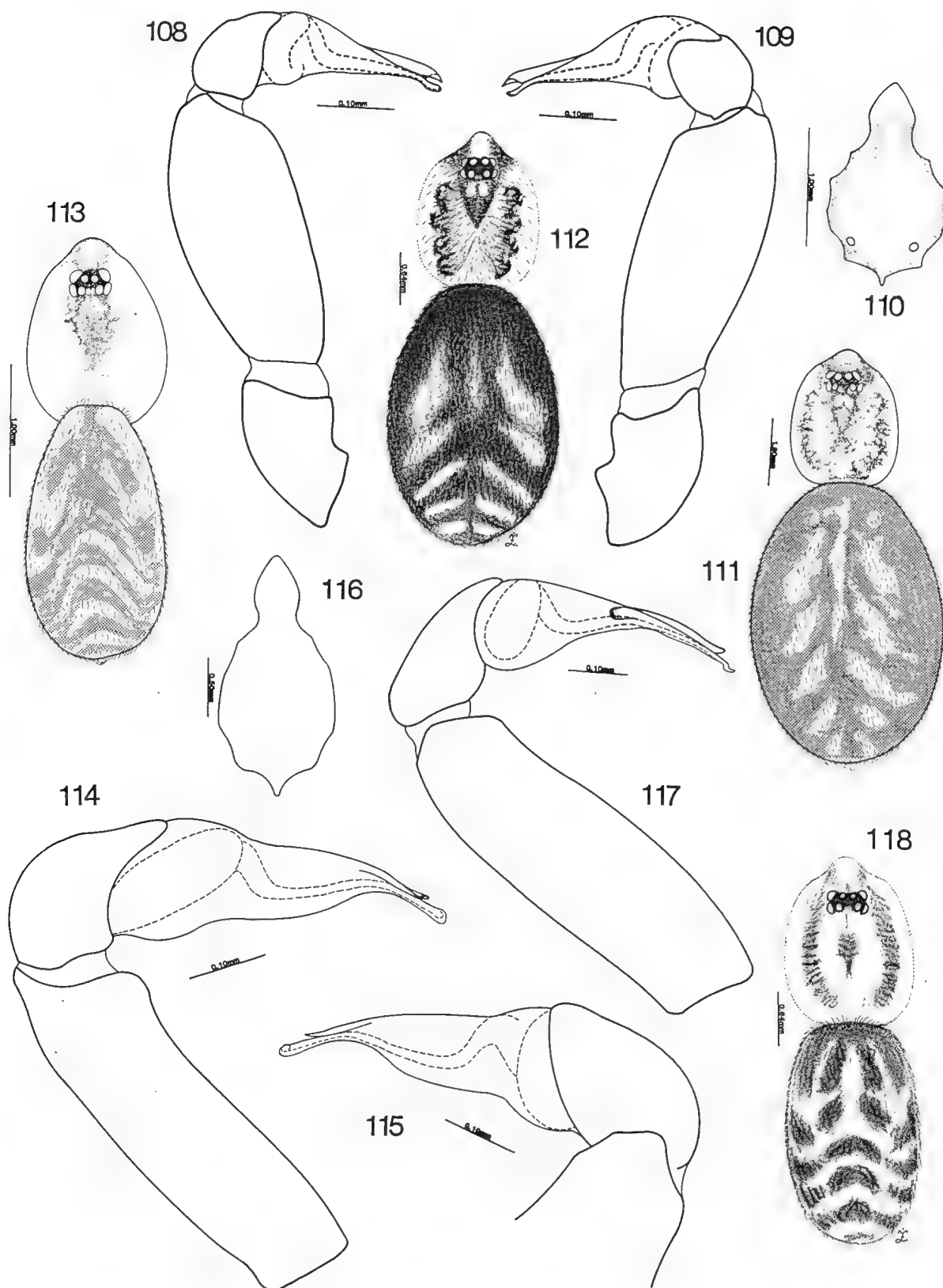
**Female.** Measurements. CL 1.95 (1.63-1.95), CW 1.50 (1.33-1.63), AL 3.28 (2.40-4.07), AW 2.21 (1.76-2.97), CIW 0.29 (0.24-0.33), EGW 0.49 (0.43-0.50), MOAL 0.30 (0.23-0.32). Dorsal body pattern Figs 111, 112; abdominal chevrons small but distinct. Sternal sigillae present, small (Fig. 110). CL : CW ratio 1 : 0.78. AME : ALE : PLE : PME 16 : 20 : 15 : 13. Legs 1423.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	2.00	1.86	1.33	1.76
Patella	0.65	0.57	0.58	0.64
Tibia	2.05	1.26	1.05	1.53
Metatarsus	1.78	1.21	1.07	1.42
Tarsus	1.27	0.80	0.68	0.80
	7.75	5.70	4.71	6.15

Tib1L : CL ratio 1 : 0.95. Lateral spermathecal lobes large, ovoid. Medial lobes long, projecting anteriorly beyond lateral lobes, and separated by the width of a lateral lobe (Figs 98-100).

**Etymology.** The specific name refers to the central Australian distribution of this species.

**Distribution.** Central Australia (Fig. 8).



**Figs 108-118.** 108-112, *Wandella centralis*: 108,109, male palp, 108, prolateral, 109, retrolateral; 110, labium, sternum; 111,112, dorsal body, female, 111, Canning Stock Route, WA, 112, Alice Springs, NT. 113-115, *W. pallida*: 113, dorsal body, female; 114,115, male palp, 114, prolateral, 115, retrolateral. 116-118, *Yardiella humphreysi*: 116, labium and sternum; 117, male palp, prolateral; 118, dorsal body, female.

*Wandella pallida* n.sp.

Figs 8, 78, 79, 101, 102, 113-115

**Type material.** HOLOTYPE, male, 90/1915 (WAM), Cave KJ-8, Jeremiah Hills, WA, 15°27'S 128°45'E, 25 June 1990, P. Drew, on stone/soil floor in dark zone (S43). PARATYPES, allotype female, 90/1916 (WAM), data as for holotype, on dust/soil floor near fine, messy, dust-coated web in humid terminating chamber (S.52)

**Diagnosis.** Weakly pigmented filistatids. AME smallest. Legs very long. Male palpal tibia elongate. Proximal part of ejaculatory duct nearer horizontal than vertical.

**Male.** Measurements. BL 3.5, CL 1.36, CW 1.12, AL 2.11, AW 1.17, CIL 0.26, EGW 3.29, MOAL 1.79. Pigmentation reduced. Carapace marginal bands reduced to absent. CL : CW ratio 1 : 0.82. AER procurved, PER weakly procurved. AME smaller than other eyes. AME : ALE : PLE : PME 7 : 11 : 10 : 8. Legs 1423, very long.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	2.90	1.99	1.63	2.17
Patella	0.50	0.46	0.45	0.47
Tibia	3.37	1.90	1.46	1.98
Metatarsus	2.96	1.76	1.64	2.15
Tarsus	1.50	0.76	0.70	0.89
	11.23	6.87	5.88	7.66

Tib1L : CL ratio 1 : 0.40. Palpal tibia long, slender, L/W ratio 1 : 0.34. Proximal limb of 'n' shaped ejaculatory duct nearer horizontal than vertical (Figs 114, 115). Paraembolic process with ragged distal margin (Figs 78, 79).

**Female.** Similar to male. Measurements. BL 3.1, CL 1.36, CW 1.06, AL 1.77, AW 0.91 CIL 0.22 EGW 3.15 MOAL 1.54. Dorsal body pattern (Fig. 113). CL : CW ratio 1 : 0.78. Eyes as in male. AME : ALE : PLE : PME 6 : 10 : 9 : 7. Sternal sigillae not seen. Legs 14(2)3, long.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	2.35	1.62	1.33	1.86
Patella	0.46	0.42	0.41	0.47
Tibia	2.66	—	1.15	1.64
Metatarsus	2.20	—	1.18	1.60
Tarsus	1.28	—	0.69	0.86
	8.95	—	4.76	6.43

Tib1L : CL ratio 1 : 0.51. Palpal tarsus long, slender. Lateral spermathecal lobes large, ovoid. Medial lobes small, short, separated by about the width of a lateral lobe (Figs 101, 102).

**Etymology.** The specific name refers to the weak pigmentation of these spiders.

**Distribution.** Known only from the type locality (Fig. 8).

*Yardiella* n.gen.

**Diagnosis.** Spines absent. Carapace mid-dorsal stripe reduced, weakly bifurcate posteriorly. AME very small. PMS with 2 spigots. Plumose and ciliate hairs present. Male palp long, slender, post-tegular prolateral dorsal surface longitudinally grooved, paraembolic process low, thickened, roofing the groove. Post-tegular groove with larger proximal and smaller distal teeth (comb-like arrays absent), dorsal paraembolic process with scaliform sculpturing. Female genitalia with four receptacula, lateral receptacula with elongate connecting ducts.

**Description.** Similar to *Wandella* except as follows. Medium sized spiders, CL up to 2.40. Carapace long, mid-dorsal stripe incomplete behind eyes, weakly bifurcate posteriorly. AER weakly procurved, PER weakly procurved to straight. ALE much larger than AME and AME much smaller than PME. Ciliate and plumose hairs present (Fig. 10). Tarsal organ Fig. 12. Trichobothria: metatarsi 1,2 with 2 long distal and 5 short central, metatarsi 3,4 with 1 long distal and 4-5 central-proximal; tibiae with 1 long distal and 1 long, 3-4 short proximal. Trichobothrial base Fig. 20. Female palp tarsus moderately long, cylindrical. Legs elongate, tibia 1 2-3 times length of carapace. Calamistrum with 3 rows of toothed setae. Male palpal tibia long, weakly incrassate (Fig. 117). Palpal organ slender, prolateral post-tegular surface with a deep, longitudinal groove, becoming shallower in distal third. Paraembolic process long, low and thickened, dorsal surface with 'scaliform' sculpturing (Fig. 122); process reflected prolaterally to form the roof of the post-tegular groove, distal end of process free, erect (Fig. 124). Post-tegular groove with large, blunt teeth proximally and pointed, procumbent teeth, the latter single or in groups of 2-3 (?comb vestiges) scattered distally along the groove (Figs 119-124). Female genitalia like *Wandella*, but lateral spermathecal lobes connected to deep bursal pockets by elongate, curved ducts (Fig. 107). Spinnerets as for *Wandella*.

**Type species.** *Yardiella humphreysi* n.sp.

**Included species.** The genus is monotypic.

**Etymology.** The genus is named after Yardie Station, North-West Cape Peninsula.

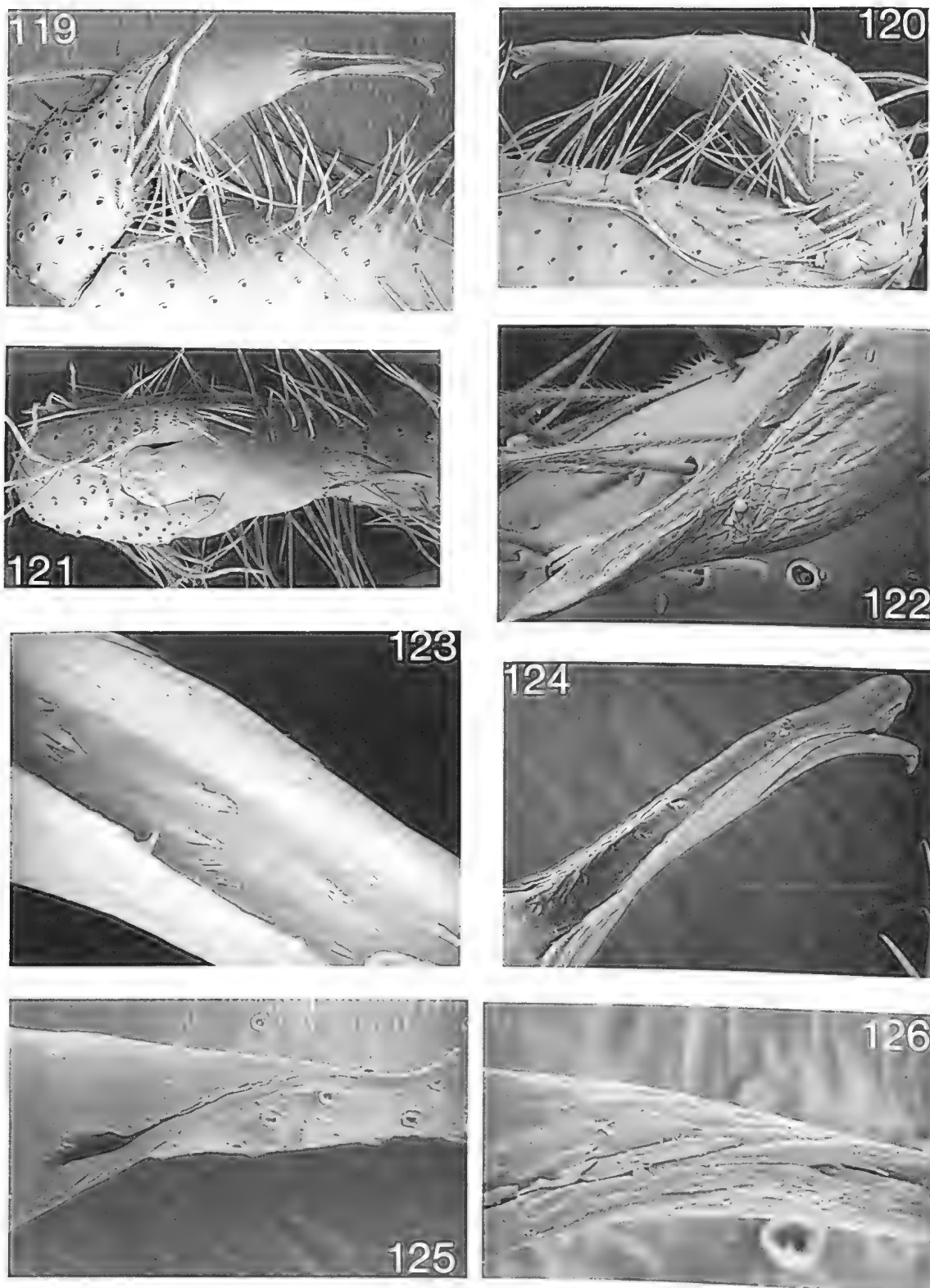
**Distribution.** North-West Cape Peninsula, WA (Fig. 8).

*Yardiella humphreysi* n.sp.

Figs 6, 8, 10, 12, 20, 107, 116-124

**Type material.** HOLOTYPE, male, (WAM), Cave C94, North-West Cape Peninsula, WA, 21°47'S 114°10'E, 20 Sept.





**Figs 119-126.** Male palp. 119-124, *Yardiella humphreysi*: 119, prolateral; 120, retrolateral; 121, dorsal; 122, post-tegular palp showing dorsal scaliform structure; 123, smaller teeth along post-tegular groove; 124, post-tegular groove, larger teeth at apex. 125, 126, Undescribed Indian species (near *Yardiella*), from Orissa, north-east India. Male palp: 125, grooved post-tegular area, dorsal; 126, part of dorsal scaliform structure.

1988, M. Gray & S. Eberhard. PARATYPES, allotype female, KS30224 (AM), data as for holotype; 2 males, KS21587, KS30226 (AM); 7 females, KS21587, KS30225, KS30227 - KS30231 (AM), data as for holotype; 9 females, 90/1889-99 (WAM), Cave C64, North-West Cape Peninsula, WA, 22°02'S 114°01'E, 27 June 1989, M. Harvey, B. Vines & E. Bowra (#3593); 3 females, 90/1900, 1902, 1903 (WAM), locality as above, 3 July 1989, D. Brooks & P. Raison, from guano pile (#4108, #4129, #4141); 1 male, 90/1910 (WAM), locality as above, 25 May 1990, J.M. Waldock (#245); 1 female, 90/1888 (WAM), Cave C199, North-West Cape Peninsula, WA, 22°12'S 113°55'E, 27 June 1989, M. East & D. Brooks (#3779).

**Diagnosis.** Medium sized spiders. Pigmentation variably reduced. AME small. Legs long, first tibia 2-3\* as long as carapace. Male palpal organ slender, with paraembolic groove.

**Male.** Measurements: BL 2.9 (2.5-3.0), CL 1.65 (1.43-1.66), CW 1.30 (1.06-1.30), CIL 0.35 (0.31-0.36), AL 2.24 (1.83-2.43), AW 1.31 (1.06-1.34), EGW 0.39 (0.34-0.39), MOAL 0.20 (0.16-0.20). Pigmentation variably reduced: on carapace, confined to submarginal bands and lateral clypeal areas, mid-dorsal pigmentation confined to eye mound and mid-dorsum; dorsal and lateral abdomen mid-dark lustrous grey with a pale, often thin, mid-dorsal stripe and 6-7 usually distinct and large, light brown lateral chevrons (Fig. 6), sometimes coalescent. Ventral body pale, unpatterned. Legs light brown, darker distally, with dark grey annulations on the femora and tibiae. CL : CW ratio 1 : 0.75. AER weakly procurved, PER recurved-straight. AME smallest, much smaller than PME. AME : ALE : PLE : PME 8 : 15 : 13 : 11. Sternal sigillae not seen. Legs 1423, very long.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	3.45	2.38	1.89	2.52
Patella	0.50	0.53	0.52	0.60
Tibia	4.38	2.28	1.70	2.31
Metatarsus	3.76	2.15	1.90	2.52
Tarsus	1.96	0.92	0.90	1.09
	14.05	8.26	6.91	9.04

Tib1L : CL ratio 1 : 0.38. Palpal tibia long, L/W ratio 1 : 0.34. Palpal organ long, slender with a highly modified paraembolic process as for genus (Figs 117, 119-124).

**Female.** Similar to male. BL 3.9 (2.9-4.1), CL 2.35 (1.65-2.40), CW 1.51 (1.34-1.66), CIL 0.45 (0.30-0.48), AL 3.8 (2.9-3.9), AW 2.54 (2.02-2.60), EGW 0.48 (0.39-0.48), MOAL 0.26 (0.20-0.26). Dorsal body pattern Figs 6, 118 (abdominal pattern somewhat variable). CL : CW ratio 1 : 0.74. AME small. AME : ALE : PLE : PME 10 : 16 : 14 : 13. Labium and sternum Fig. 116. Legs 1423, long.

	Leg 1	Leg 2	Leg 3	Leg 4
Femur	3.78	2.50	2.11	2.93
Patella	0.69	0.64	0.67	0.77
Tibia	4.49	2.34	1.66	2.54
Metatarsus	3.70	2.05	1.82	2.44
Tarsus	1.97	0.99	0.93	1.13
	14.63	8.52	7.19	9.81

Tib1L : CL ratio 1 : 0.53. CW : PalpFemL ratio 1 : 0.97. Palpal tarsus slender. Lateral spermathecal lobes

spherical with few secretory tubules and set upon elongate, curved, tube-like necks (Fig. 107). Smaller medial lobes separated by 0.5-1 times the width of a lateral lobe.

**Etymology.** The species is named in recognition of Dr Bill Humphreys' contribution to our knowledge of the North-West Cape cavernicolous fauna.

**Biology.** These are the largest of the Australian filistatid spiders. The small AME, long legs and somewhat reduced body pigment suggest that this may be a cave-obligate species. They have never been found on the surface, despite their occurrence in twilight as well as dark, cave zones. Their webs are irregular shawls with funnel entrances, built among rocks and roots on the cave floor, walls and roof. They are often associated with bat guano deposits. Males and females were observed occupying the same web.

**Distribution.** North-West Cape Peninsula, WA (Fig. 8).

**ACKNOWLEDGMENTS.** Dr M. Harvey and Ms J. Waldock (WAM), Dr R. Raven (QM), Mr D. Hirst (SAM) and Mr D. Ubick (CAS) kindly made available material from collections in their care. I am grateful to Dr G. Rack (ZMH) and Mlle J. Rollard (MNHN) for their assistance when visiting their institutions. Dr W. Humphreys provided the opportunity for me to participate in his field work program at North-West Cape, WA. Technical assistance was provided by Judith Thompson and Christine Horseman. Judith Thompson, Jane McRae and Marek Zabka provided illustration assistance. This research was supported by an Australian Research Council grant.

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## Early Carboniferous Gastropoda from the Tamworth Belt, New South Wales, Australia

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**ABSTRACT.** Rich faunas of minute, Early Carboniferous gastropods, elegantly preserved as chloritic replacements, are documented from the Rangari Limestone Member of the Tulcumba Sandstone (early to middle Tournaisian), the Namoi Formation (middle to late Tournaisian), the Dangarfield Formation (late Tournaisian) and the uppermost part of the Kyndalyn Mudstone Member of the Merlewood Formation (middle or late Visean) of eastern New South Wales. Seven new genera *Campbellospira*, *Globobulimorpha*, *Microcochlis*, *Kyndalynia*, *Palaeoalvania*, *Kimina* and *Pseudoaclisina* are proposed. Of the 79 gastropod species (referable to 47 genera and subgenera), 40 are described as new: *Euphemites pustula*, *Cymbularia carinata*, *Bellerophon* (*Bellerophon*) *kyndalynensis*, *Bellerophon* (*B.*) *swainsensis*, *Knightites* (*Retispira*) *multilirata*, *Knightites* (*R.*) *triangularis*, *Straparollus brevis*, *Serpulospira scalariformis*, *Platyschisma lingua*, *Platyschisma vitrea*, *Angyomphalus radianodosa*, *Eotomaria umbilicata*, *Campbellospira conica*, *Glabrocingulum pustulum*, *Hesperiella elongata*, *Hesperiella planorbis*, *Agnesia reticulata*, *Worthenia crenilunula*, *Gyronema nacreformis*, *Rhabdotocochlis turgida*, *Naticopsis* (*Naticopsis*) *minuta*, *Palaeozygopleura obesa*, *Pseudozygopleura gracilis*, *Leptozyga costata*, *Ceraunocochlis australis*, *Ceraunocochlis tenuis*, *Strobeus ovalis*, *Girtyspira inflata*, *Globobulimorpha costata*, *Microcochlis parva*, *Eucochlis depressa*, *Eucochlis umbiliparva*, *Kyndalynia inflata*, *Kimina australis*, *Kimina minor*, *Kimina globosa*, *Pseudoaclisina microspirulata*, *Palaeoalvania talenti*, *Donaldina minutissima*, *Streptacis gundyensis*. Seventeen additional forms are discriminated but because of bad preservation or dearth of material they are not named. *Campbellospira*, characterised by a planktotrophic protoconch with a selenizone and long slit is assigned to Pleurotomarioidea. *Globobulimorpha*, an unusual globular fusiform shell with a columellar fold and deviated protoconch is tentatively assigned to Subulitoidea. *Kimina* and *Palaeoalvania* are placed in Order Heterogastropoda. *Aclisina turgida* Yoo is made the basis of a new genus *Pseudoaclisina* and transferred from Murchisonioidea to Order Heterogastropoda. *Stegocoelia* is transferred from Murchisonioidea to Loxonematoidea. It is not possible at present to place three genera, *Microcochlis*, *Kyndalynia* and *Eucochlis* in any existing Order.

### Aims and Scope of Present Study

Early Carboniferous brachiopods and conodonts of the Tamworth Belt have been the subject of a number of exhaustive studies in recent years (Campbell, 1957, 1961; Campbell & McKellar, 1969; Roberts, 1963, 1965, 1975; Jenkins, 1974; Crane, 1975 unpublished; Mory, 1980 unpublished; Mory & Crane, 1982). Gastropods from the same horizons have received relatively little attention, largely because they were thought to be poorly preserved, had evolved slowly and, accordingly, had little value for stratigraphic correlation. Literature of interest on other invertebrate groups includes ammonites (Delepine, 1941; Campbell *et al.*, 1983), crinoids (Campbell & Bein, 1971; Pickett, 1960), corals (Pickett, 1966), bryozoans (Engel, 1975; Campbell & Engel, 1963), and trilobites (Engel & Morris, 1983, 1984, 1985).

Carboniferous molluscs have been known in New South Wales since the work on a fauna from the Port Stephens District (Etheridge, 1890a,b) and other areas (Etheridge, 1890c, 1891, 1896, 1898, 1902, 1907). Occasional descriptions of molluscs (de Koninck, 1876; Dun & Benson, 1920; Campbell, 1962) and faunal lists (Benson, 1921) have appeared. New species of molluscs have been described in papers devoted to faunas from the Werrie and Belvue Synclines (Campbell & Engel, 1963), from Barrington (Campbell & McKelvey, 1971), from Old Cannindah, Queensland (Maxwell, 1961), and from the Dangarfield Formation near Gundy, Hunter Valley (Yoo, 1988).

The aim of this study is to make an extensive search for additional similarly well preserved material that might contribute to better understanding of the evolution of the Late Palaeozoic Gastropoda, especially of minute taxa which, because of poor preservation, are rarely investigated. Samples from 13 localities out of 42 localities examined in the Mandowa Formation, Luton Formation, Tulcumba Sandstone, Namoi Formation, Caroda Formation, Merlewood Formation, Dangarfield Formation and Woolooma Formation, yielded some 3,000 well preserved gastropods. The specimens were classified to the species level, where possible, and for systematic arrangement, the Treatise on Invertebrate Paleontology Part I, Mollusca 1 (Knight *et al.*, 1960) was generally followed. However, the placement of many groups remains uncertain. Many species discussed here belong to existing genera which until recently have been placed in the Order 'Archaeogastropoda'. Recent phylogenetic studies based on anatomical features (Haszprunar, 1988) have shown that this order is an unnatural grouping. The name 'Archaeogastropoda' is retained here until we have a better idea of their phylogeny.

### Preservation and Deposition of Material

Replacement of the mollusc shells by chlorite, sulfate and silicate was discussed by Ladd (1959), Tasch (1973), Bandel (1988), Yoo (1988) and others. Chlorite is one

of the most common secondary minerals occurring in the Early Carboniferous sediments of the Tamworth Belt. During the process of low-grade metamorphism, less stable minerals such as calcite, aragonite and clay minerals were partly replaced. This replacement has made the isolation of complete shells even those with thin and delicate ornamentation possible. All photographs illustrated in the plates were obtained using a JEOL JSM 840 stereoscan electron microscope, at Macquarie University.

All type specimens are given the Australian Museum Register Numbers unless stated otherwise, and are housed in the Australian Museum, Sydney. Plates are listed in the Appendix.

### Abbreviations

DA – maximum diameter of aperture; GR – grid reference; H – height; MD – maximum diameter of whorl; NL – number of lirae; NW – number of whorl; PA – pleural angle; TS – thickness of spire; W – width.

### Regional Geological Setting

The area investigated in this study is a long (280 km), narrow (13 km) belt stretching from Gravesend southwards to the Glenbawn Dam in the Upper Hunter Valley (Fig. 1) which is part of the Tamworth Belt.

The Tamworth Belt forms the western and southern margin of the New England Fold Belt, and lies between the Hunter-Mooki Thrust on the west and the Peel Fault to the east, parallel to it (Leitch, 1974; Korsch, 1977). West and south of the Hunter-Mooki Thrust, the belt is bordered by the Permian sediments of the Sydney-Gunnedah Basin. The Tamworth Belt extends for about 410 km, emerging from below Mesozoic sediments of the Surat Basin near Gravesend in the north, trending south-south-east, and swinging south-easterly at the Liverpool Range towards the eastern coast between Newcastle and Taree (Fig. 1) (Mory, 1980). It is 50 km wide with a stratigraphic thickness of approximately 10 km (Mory, 1980) comprising Late Palaeozoic rocks, principally Devonian marine sediments overlain by the marine to non-marine Carboniferous sediments outcropping parallel in the west; the tract of Carboniferous sediments is generally about 10 to 20 km in width. The sediments within the belt are faulted and folded. North of the Liverpool Range, structures are generally parallel or subparallel to the axis of the Belt with the Rocky Creek and Belvue-Werrie Synclines being the most prominent.

### Stratigraphy

Selected stratigraphic nomenclature of Early Carboniferous units in the northern Tamworth Belt and

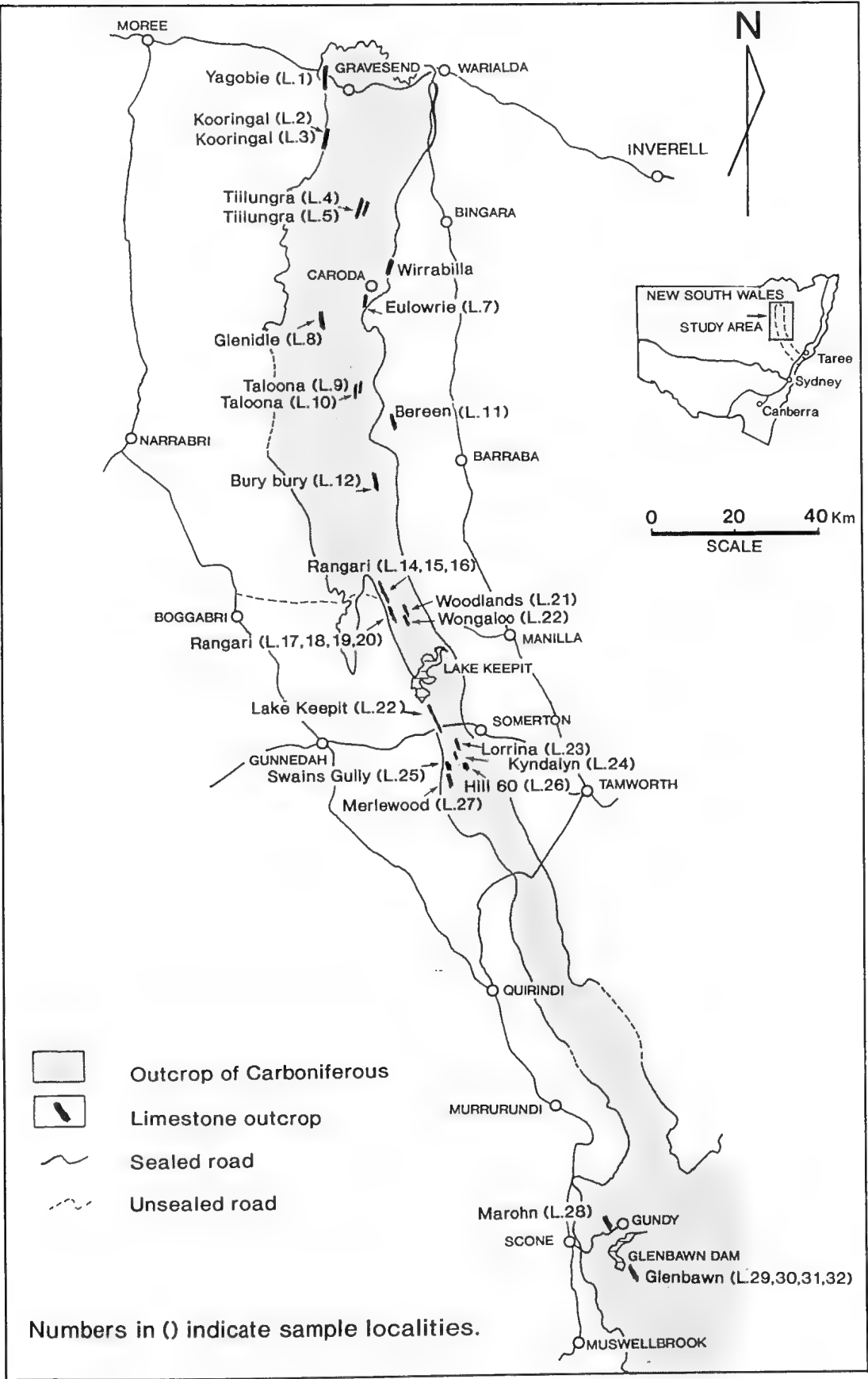


Fig. 1. Distribution of Carboniferous outcrop and examined localities.

in the Glenbawn Dam area is shown in Figure 2. The base of the Early Carboniferous has been taken to approximate the base of the Luton Formation in the Rocky Creek Syncline, the Tulcumba Sandstone in the Belvue-Werrie Syncline, and the upper part of the Kingsfield Formation in the Glenbawn Dam area. The upper boundary approximates the top of the Caroda Formation in the Rocky Creek Syncline, the top of the Merlewood Formation in the Belvue-Werrie Syncline, and the top of the Isismurra Formation in the Glenbawn Dam area (McKelvey & White, 1964; Voisey & Williams, 1964; White, 1964; Roberts & Oversby, 1974; Moore & Roberts, 1976; Mory, 1978, 1980, 1982).

Examined Localities

The examined localities are shown in Figure 1. The detail of the localities are as follows:

**Locality 1 (Yagobie)** - Gravesend 1:50,000, GR 365 278. Skeletal limestone interbedded in mudstone of the Namoi Formation. There are 5 bands of limestone ranging in thickness from 0.1 to 0.2 m. No gastropods were recovered.

**Locality 2 (Koorinal)** - Gravesend 1:50,000, GR 361 107. Oolitic skeletal limestone containing bryozoans, crinoids, calcareous algae, echinoderm plates, and shell fragments in the Namoi Formation, 100 m south of 'Koorinal' homestead. Only internal molds of gastropods were recovered.

**Locality 3 (Koorinal)** - Gravesend 1:50,000, GR 360 108. Oolitic limestone interbedded in mudstone of the Namoi Formation, about 75 m stratigraphically higher than Locality 2. No gastropods were recovered.

**Localities 4 & 5 (Tiilungra)** - Terry Hie Hie 1:50,000,

GR 443 962. Oolitic and bioclastic limestone lenses in the Luton Formation, on the disused roadsides, 1.8 and 1.1 km west of 'Tiilungra' homestead respectively. No gastropods were recovered.

**Locality 7 (Eulowrie)** - Eulowrie 1:25,000, GR 472 732. Oolitic limestone in the Luton Formation, 3 m thick in a small gully, 0.5 km north-west of 'Kingsland' homestead. No gastropods were recovered.

**Locality 8 (Glenidle)** - Eulowrie 1:25,000, GR 375 652. Oolitic limestone in the Caroda Formation, up to 8 m thick behind a woolshed, on the eastern side of the Back Creek road near 'Glenidle'. No gastropods were recovered.

**Locality 9 (Taloona)** - Horton 1:25,000, GR 460 521. Oolitic-skeletal limestone in the Namoi Formation, containing fragments of bryozoans, crinoids, echinoderm spines. No gastropods were recovered.

**Locality 10 (Taloona)** - Horton 1:25,000, GR 463 518. Crinoidal limestone in the Namoi Formation, 5 m thick, 300 m stratigraphically higher than Locality 9. No gastropods were recovered.

**Locality 11 (Bereen)** - Horton 1:25,000, GR 508 519. Fine-grained limestone bands in the Namoi Formation, 0.8 km south of 'Bereen' homestead. The limestones are not fossiliferous.

**Locality 12 (Burybury)** - Horton 1:25,000, GR 504 314. Crinoidal limestone in the Namoi Formation, 1.5 km south of 'Pembury' homestead. No gastropods were recovered.

**Locality 14 (Rangari)** - Willuri 1:25,000, GR 506 044. Grey crystalline bioclastic limestone in the Rangari Limestone Member of the Tulcumba Sandstone, 1.7 km north of 'Rangari' homestead.

**Locality 15 (Rangari)** - Willuri 1:25,000, GR 513 037. Grey crinoidal bioclastic limestone in the Rangari Limestone Member of the Tulcumba Sandstone, 1.5 km

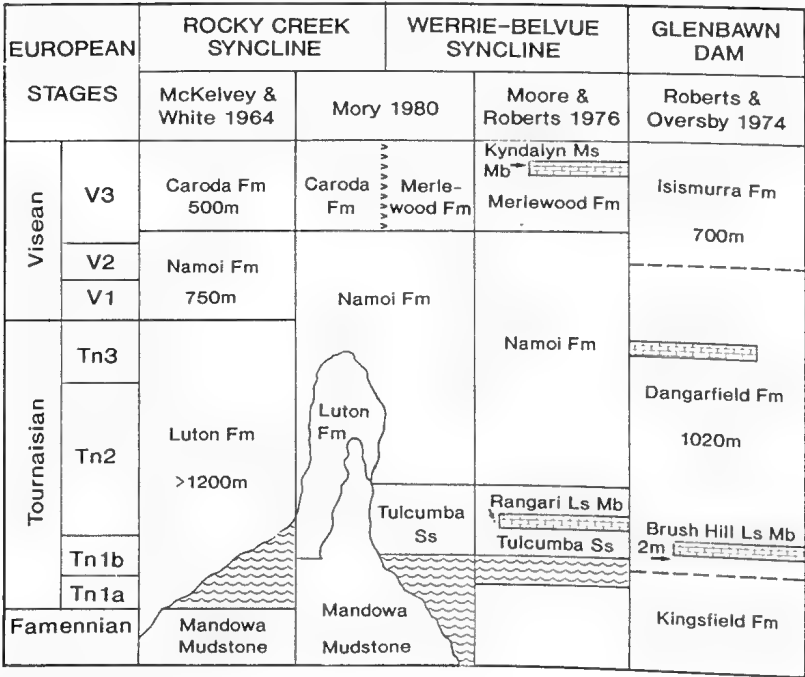


Fig. 2. Stratigraphic nomenclature.



north-east of 'Rangari' homestead.

**Locality 16 (Rangari)** - Willuri 1:25,000, GR 507 043. 0.8 km north-west of Locality 15, on the same limestone band.

**Locality 17 (Rangari)** - Willuri 1:25,000, GR 525 999. The lower limestone band (oolitic limestone, 2 m thick) of the Rangari Limestone Member, 4 km south-east of 'Rangari' homestead.

**Locality 18 (Rangari)** - Willuri 1:25,000, GR 527 998. The middle band (bioclastic limestone) of the Rangari Limestone Member, approximately 150 m north-east of Locality 17.

**Locality 19 (Rangari)** - Willuri 1:25,000, GR 528 998. The upper band (sandy bioclastic limestone) of the Rangari Limestone Member, 130 m north-east of Locality 18.

**Locality 20 (Rangari)** - Willuri 1:25,000. GR 539 024. Crystalline limestone in the Namoi Formation, 1.3 km south-west of the cross road between Gunnedah-Barraba and Manilla-Boggabri roads.

**Locality 21 (Woodlands)** - Willuri 1:25,000, GR 567 014. Well sorted, fine-grained sandy limestone in the Tulcumba Sandstone. It is not fossiliferous.

**Locality 22 (Lake Keepit)** - Somerton 1:25,000, GR 642 728. Crinoidal limestone in the Tulcumba Sandstone, 100 m north of the junction of Oxley Highway and Lake Keepit road.

**Locality 23 (Lorrina)** - Somerton 1:25,000, GR 708 697. Bioclastic limestone in the upper part of the Namoi Formation, containing fragments of corals, crinoids, bryozoans and gastropods.

**Locality 24 (Kyndalyn)** - Somerton 1:25,000, GR 694 679. Oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation, up to 5 m thick, behind 'Kyndalyn' homestead, 10 km south-west of Somerton.

**Locality 25 (Swains Gully)** - Winton 1:25,000, GR 673 638. Fossiliferous limestone in the Namoi Formation in Swains Gully, approximately 250 m west of the Babbins Lane. This is one of the localities which have produced rich gastropod faunas.

**Locality 26 (Hill 60)** - Winton 1:25,000, GR 693 641. Bioclastic and oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation, up to 30 m thick, 1.9 km upstream in Swains Gully from the Babbins Lane.

**Locality 27 (Merlewood)** - Winton 1:25,000, GR 674 621. Merlewood Formation, 100 m east of Babbins Lane, 0.8 km north of 'Merlewood'.

**Locality 28 (Marohn)** - Scone 1:25,000, GR 084 544. Bioclastic limestone in the upper part of the Dangarfield Formation, 150 m west of 'Marohn' homestead, 4 km south-west of Gundy.

**Locality 29 (Glenbawn)** - Woolooma 1:25,000, GR 132 453. The uppermost limestone band in the Dangarfield Formation, 1.7 km east of Glenbawn Dam.

**Locality 30 (Glenbawn)** - Woolooma 1:25,000, GR 131 452. A coarse grained crystalline limestone 0.2 m thick, 11 m lower than Locality 29.

**Locality 31 (Glenbawn)** - Woolooma 1:25,000, GR 130 452. Muddy limestone and calcareous sandstone

ranging from 0.14 m to 0.2 m in a 3m interval, approximately 25 m lower than Locality 30.

**Locality 32 (Glenbawn)** - Woolooma 1:25,000, GR 129 453. Muddy limestone 0.12 m thick, 6 m lower than Locality 31.

### Occurrence of Gastropod Faunas and Comparison with other Faunas

In three areas, (1) 'Rangari', (2) Swains Gully-'Kyndalyn' and (3) 'Marohn'-Glenbawn Dam, a large number of identifiable gastropod specimens was recovered from four different time units; early to middle Tournaisian, middle Tournaisian, late Tournaisian, and middle or late Viséan. Figure 3 shows the occurrences and ranges of the faunas.

Five brachiopod zones (Roberts, 1975) and seven conodont zones (Jenkins, 1974; Mory, 1980) have been discriminated in the Early Carboniferous of the study area. The stratigraphic positions of gastropod localities in relation to the pattern of brachiopod and conodont zones are shown in Figure 4.

**'Rangari' area.** Rangari Limestone Member of Tulcumba Sandstone. The bioclastic limestone of the Rangari Limestone Member yielded a large number of gastropods, particularly from the middle band in the Rangari area (Localities 14, 15 and 18). The lowest of the brachiopod zones, that of *Tulcumbella tenuistriata* (early Tournaisian) has been identified at 80 m below the top of the Tulcumba Sandstone in Swains Gully by Roberts (1975). The Rangari Limestone Member at 'Rangari' is the oldest unit from which gastropods are recovered in this study. Brachiopod faunas from the top of the Tulcumba Sandstone (L76 University of New England) and the base of the Namoi Formation (L77 University of New England), both at 'Rangari', are indicative of the *Spirifer sol* Zone, indicating a middle Tournaisian age (Roberts, 1975). Conodonts of the lower *crenulata* Zone from 7 m above the base of the Tulcumba Sandstone indicate that the formation is late Kinderhookian (middle Tournaisian) in age (Mory, 1980).

**Swains Gully-'Kyndalyn' area.** Namoi Formation. Major parts of the fauna for this study are recovered from a bioclastic limestone, 130 m above the base of the Namoi Formation in Swains Gully (Locality 25). This horizon is referred to the *Spirifer sol* Zone (middle Tournaisian); the remainder of the Namoi Formation is referred to the *Schellwienella cf. burlingtonensis* Zone (late Tournaisian) by Roberts (1975). Conodonts of the *isosticha*-upper *crenulata* Zone are recovered 2.5 m above the base of the Namoi Formation at 'Rangari', indicating lower part of the formation to be still middle Tournaisian in age (Mory, 1980). Conodonts indicative of the *Scaliognathus anchoralis* Zone (late Tournaisian) have been recovered from the upper limestone band of the formation in Swains Gully (Jenkins, 1974; Mory, 1980). A small number of gastropods recovered at 'Lorrina' (Locality 23), is thought

EUROPEAN STAGES	Tournaisian											M/L Viséan
	Early to Mid			Mid Swains Gully L.25	Late					Lorina L.23	Kyndalyn L.24	
	Rangari				Glenbawn							
SAMPLE LOCALITIES	L.22-2	L.18	L.15	L.14	L.32	-2	L.31	-1	L.30	L.29	L.28	Marohn
<b>GASTROPOD FAUNAS</b>												
Order Uncertain												
SF Bellerophontoidea												
<i>Sinuinitina portulacoides</i> Campbell & Engel												
<i>Euphemites labrosa</i> Campbell & Engel												
<i>Euphemites pustula</i> n. sp.												
<i>Cymbularia carinata</i> n. sp.												
<i>Bellerophon</i> (B.) <i>kyndalynensis</i> n. sp.												
<i>Bellerophon</i> (B.) <i>swainsensis</i> n. sp.												
<i>Knightites</i> (R.) <i>cullenii</i> Campbell & Engel												
<i>Knightites</i> (R.) <i>multilirata</i> n. sp.												
<i>Knightites</i> (R.) <i>triangularis</i> n. sp.												
Order 'Archaeogastropoda'												
SF Euomphaloidea												
<i>Onychochilus minutissimus</i> Yoo												
<i>Straparollus brevis</i> n. sp.												
<i>Straparollus davidi</i> Dun & Benson												
' <i>Serpulospira</i> ' <i>scalariformis</i> n. sp.												
SF Pleurotomarioidea												
<i>Platyschisma lingua</i> n. sp.												
<i>Platyschisma vitrea</i> n. sp.												
<i>Angyomphalus radianodosa</i> n. sp.												
<i>Eotomaria umbilicata</i> n. sp.												
<i>Glabrocingulum obesum</i> Yoo												
<i>Glabrocingulum pustulum</i> n. sp.												
<i>Glabrocingulum</i> sp.												
<i>Campbellospira conica</i> n. gen & n. sp.												
<i>Campbellospira</i> sp. A												
<i>Campbellospira</i> sp. B												
<i>Campbellospira</i> sp. C												
<i>Hesperiella elongata</i> n. sp.												
<i>Hesperiella planorbis</i> n. sp.												
<i>Hesperiella robertsi</i> Yoo												
<i>Agnesia reticulata</i> n. sp.												
<i>Peruvipsira gundyensis</i> Yoo												
<i>Worthenia crenilunula</i> n. sp.												
<i>Worthenia</i> sp.												
<i>Ruedemannia</i> sp.												
<i>Borestus costatus</i> Yoo												
SF Patelloidea												
' <i>Lepetopsis</i> ' sp.												
SF Trochoidea												
<i>Araeonema microspirulata</i> Yoo												
<i>Rhabdotocochlis turgida</i> n. sp.												
<i>Gyronema nacreiformis</i> n. sp.												
<i>Microdoma angulata</i> Yoo												
SF Neritoidea												
<i>Naticopsis</i> (N.) <i>minuta</i> n. sp.												
<i>Naticopsis</i> (N.) <i>osbornei</i> Yoo												
<i>Turbonitella</i> sp.												
Order Uncertain												
SF Murchisonioidea												
<i>Murchisonia</i> sp.												
Order Caenogastropoda												
SF Loxonematoidea												
<i>Stegococclia</i> (S.) <i>nodosa</i> Yoo												
<i>Stegococclia</i> (H.) <i>elongata</i> Yoo												
<i>Stegococclia</i> (H.) <i>tenuis</i> Yoo												
<i>Stegococclia</i> (H.) sp. A												
<i>Stegococclia</i> (H.) sp. B												
<i>Palaeozygopleura obesa</i> n. sp.												
<i>Pseudozygopleura gracilis</i> n. sp.												
<i>Leptozyga costata</i> n. sp.												
<i>Hemizygma decussata</i> Yoo												
<i>Cyclozyga sinuigera</i> Yoo												
<i>Cyclozyga</i> sp.												
SF Subulitoidea												
<i>Ceraunocochlis australis</i> n. sp.												
<i>Ceraunocochlis tenuis</i> n. sp.												
<i>Strobeus ovalis</i> n. sp.												
<i>Soleniscus callosus</i> Yoo												
<i>Soleniscus</i> sp.												
<i>Girtyspira inflata</i> n. sp.												
<i>Globbulimorpha costata</i> n. gen & n. sp.												
Order Uncertain												
SF Uncertain												
<i>Microcochlis parva</i> n. gen & n. sp.												
<i>Eucochlis australis</i> Yoo												
<i>Eucochlis depressa</i> n. sp.												
<i>Eucochlis umbiliparva</i> n. sp.												
<i>Eucochlis</i> sp.												
<i>Kyndalynia inflata</i> n. gen & n. sp.												
Order Heterogastropoda												
SF Uncertain												
<i>Kimina australis</i> n. gen & n. sp.												
<i>Kimina globosa</i> n. sp.												
<i>Kimina minor</i> n. sp.												
<i>Kimina</i> sp.												
<i>Palaeoalvania talenti</i> n. gen & n. sp.												
<i>Pseudoacclisina microspirulata</i> n.gen & sp.												
<i>Pseudoacclisina turgida</i> (Yoo)												
Order Opisthobranchia												
SF Uncertain												
<i>Donaldina filosa</i> Yoo												
<i>Donaldina minutissima</i> n. sp.												
<i>Donaldina</i> sp.												
<i>Streptacis elegantissima</i> (Yoo)												
<i>Streptacis gundyensis</i> n. sp.												
<i>Streptacis</i> sp.												

Fig. 3. Occurrences of Early Carboniferous gastropods from the Tamworth Belt.

to come from the same stratigraphic level.

**Kyndalyn Mudstone Member of Merlewood Formation.** The oolitic limestone at 'Kyndalyn' (Locality 24) yielded well preserved gastropods of a middle or late Visean age. The gastropods and many other invertebrates occurring in the mudstone and oolitic limestone indicate that the sediments were deposited in a shallow marine environment (Moore & Roberts, 1976). Brachiopods from the limestones of this Member are assigned to the *Gigantoproductus tenuirugosus* Subzone of the *Delpinea aspinosa* Zone, indicating a middle late Visean (V3b) age (Roberts, 1975; Jones *et al.*, 1973; Jones & Roberts, 1976). Two conodont species, *Patrognathus* sp. and *Rhachistognathus* cf. *muricatus* are recovered from this unit (Mory, 1980). Earlier Jenkins (1974) discriminated the *Patrognathus* cf. *capricornis* Zone in the upper part of the Flagstaff Formation at Brownmore and Lewinsbrook (equivalent to the upper part of the Merlewood Formation, including the Kyndalyn Mudstone Member), and suggested an early Visean age. The Brownmore section is the reference section for the *Gigantoproductus tenuirugosus* Subzone (middle late Visean) of Roberts (1975). Later Jenkins reconsidered the conodont faunas from the Kyndalyn Mudstone Member and the Flagstaff Formation, and assigned them a middle Visean age (Jenkins, personal communication). Accordingly there is some divergence between the ages indicated by the brachiopods and ages suggested by conodonts.

**'Marohn'-Glenbawn Dam area. Upper part of Dangarfield Formation:** The bioclastic limestone of the Dangarfield Formation was resampled at 'Marohn' (Locality 28), and from several different horizons at Glenbawn Dam (Localities 29 to 32). The samples yielded a large assemblage of gastropods. Roberts and Oversby (1974) referred these horizons to the *Schellwienella* cf. *burlingtonensis* Zone, indicating a late Tournaisian age. Conodonts indicative of the *Scaliognathus anchoralis* and *Gnathodus* sp. A (Jenkins) Zones from the same horizons indicate the same age (Jenkins, 1974).

### Systematic Palaeontology

Gastropoda Cuvier, 1797

Order Uncertain

Bellerophontoidea M'Coy, 1851

Sinuittidae Dall, 1913

Bucanellinae Koken, 1925

*Sinuittina* Knight, 1945

**Australian Carboniferous species. *Sinuittina portulacoides* Campbell & Engel (1963).**

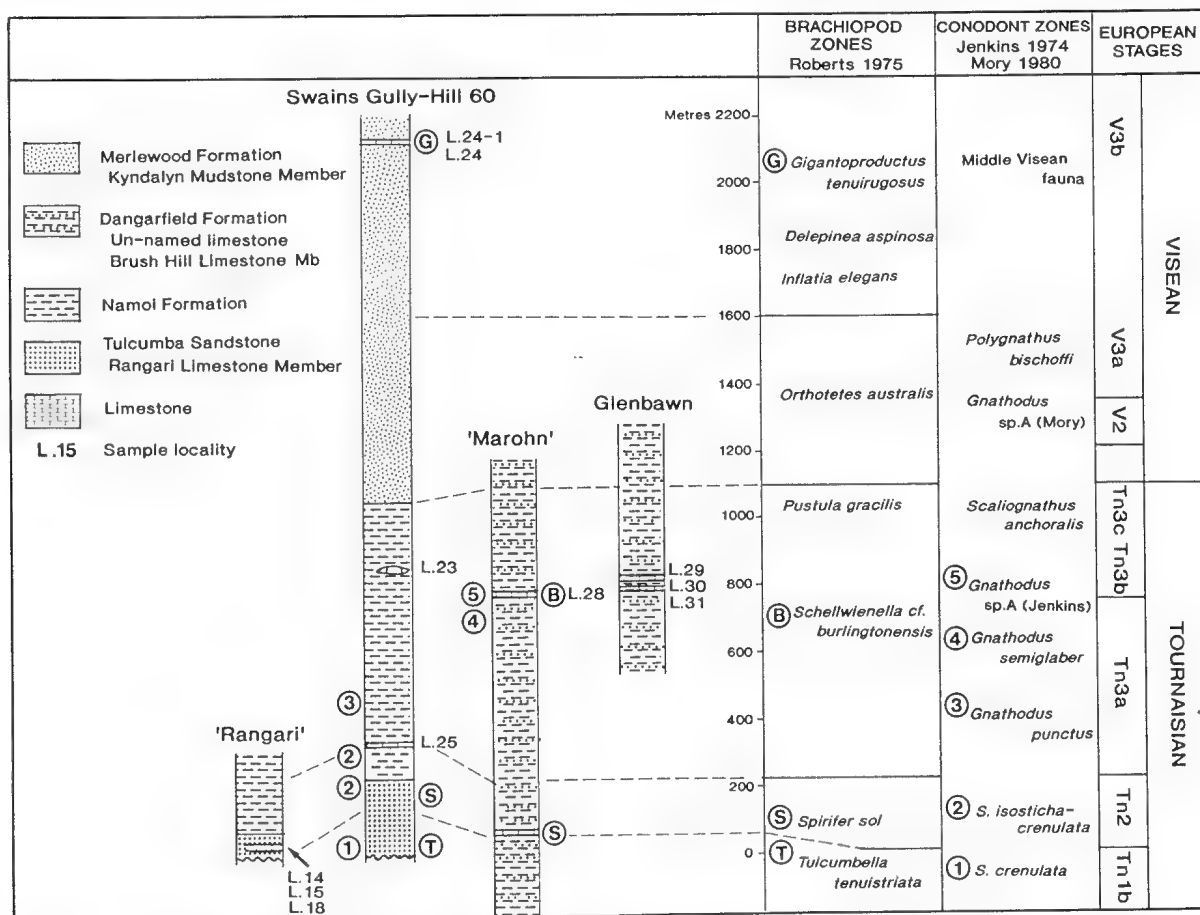


Fig. 4 Stratigraphic correlations of gastropod localities and comparison with brachiopod and conodont zones.

*Sinuitina portulacoides* Campbell & Engel

*Sinuitina portulacoides* Campbell & Engel, 1963: 90, pl.6 figs 20-24.

*Sinuitina portulacoides* Campbell & Engel.-Yoo, 1988: 239.

**Dimensions.** Figured specimen (F78340) MD 13.4 mm, TS 8.8 mm.

**Type.** The types have been transferred from the University of New England (UNE F7573, 7574-7580) to the Australian Museum, Sydney.

**Material.** 7 specimens from Swains Gully (Locality 25); 9 from 'Marohn' (Locality 28); 2 from south-east of 'Rangari' (Locality 18); 9 from Glenbawn (Localities 30, 31 and 32).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Remarks.** The specimens from Swains Gully are smaller than the type (16 mm in diameter of the last whorl), but is larger than the specimens recovered from 'Marohn', Upper Hunter Valley. All specimens are regarded as the same species.

**Euphemitinae** Knight, 1956*Euphemites* Warthin, 1930

**Australian Carboniferous species.** *Euphemites labrosa* Campbell & Engel, 1963, from 'Rangari'; *Euphemites minutus* Maxwell, 1961: 62, pl. 7 figs 1-4, Late Tournaisian-Early Viséan, Yarrol, Queensland; *Euphemites pustula* n.sp., from the lower part of the Namoi Formation.

*Euphemites labrosa* Campbell & Engel

*Euphemites labrosa* Campbell & Engel, 1963: 91, pl.6 figs 34-39.

*Euphemites labrosa* Campbell & Engel.-Yoo, 1988: 239.

**Dimensions.** Figured specimen MD 1.32 mm, TS 1.10 mm

**Types.** The types have been transferred from the University of New England (UNE F7569-7572) to the Australian Museum, Sydney.

**Material.** 17 specimens from Swains Gully (Locality 25) and 44 from 'Marohn' (Locality 28).

**Geographic distribution.** 'Rangari' to 'Marohn'.

**Geological age.** Middle to late Tournaisian.

**Remarks.** The specimens from 'Rangari', Swains Gully and 'Marohn' are identical in shell characters, although the specimens from 'Marohn' represent much smaller in size.

*Euphemites pustula* n.sp.

Pl. 1 figs 1-3

**Description.** Shell very small, relatively thin shelled, symmetrically coiled planispiral, anomphalous. Protoconch concealed, seemingly minute, planispiral. Teleoconch planispiral with involute whorls; last whorl completely embracing earlier whorls; about 18 strong sharp spiral cords in the first half volution; perinductura pustules continuing from the spiral cords occur in the last half volution; selenizone obscured by perinductura; shell consisting of 2 layers. Height of aperture corresponds to that of shell; slit seemingly broad and small.

Dimensions.	MD	TS	NL
Holotype (F78341)	4.6 mm	18 mm	—
Paratypes (F78342a)	3.4	18	—
(F78342b)	4.2	3.5	17

**Types.** Holotype (F78341), 2 figured paratypes (F78342) and 4 additional paratypes (F78529).

**Type locality.** About 250 m west of Babbins Lane, Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of Namoi Formation.

**Geographic distribution.** Swains Gully.

**Geological age.** Middle Tournaisian.

**Etymology.** Referring to perinductura pustules.

**Remarks.** *Euphemites minutus* Maxwell and *Euphemites labrosa* Campbell & Engel both have a globular form with a narrow and deep umbilicus. *Euphemites pustula* n.sp. resembles *E. minutus* in having a number of spiral cords, but differs in having a narrow peripheral profile, perinductura pustules and in lacking an umbilicus. The mode of life and shell structure of *Euphemites* has been discussed by Moore (1941), Yochelson (1960), Linsley (1978b), and Harper & Rollins (1985). *Euphemites pustula* is characterised by perinductura pustules which appear to be the continuation of the spiral cords of the shell. The shells also lack the second layer of coinductura in and adjacent to the aperture. *Euphemites pustula* would have had mantle flaps covering almost the entire shell lacking the secondary deposit of coinductura.

**Bellerophontidae** M'Coy, 1851**Bellerophontinae** M'Coy, 1851*Cymbularia* Koken, 1896

**Australian Carboniferous species.** *Cymbularia carinata* n.sp., from Swains Gully.

**Remarks.** The present specimens resemble *Warthia* Waagen (1880) in having a convolute spire and in lack of ornamentation, but differs in that *Warthia* has a rounded margin and short, wide slit.

*Cymbularia carinata* n.sp.

Pl. 1 fig. 4

**Description.** Shell very small with rather thick, biconvex lenticular form, isostrophic and smooth with an acute keel at periphery; umbilici closed on both sides by last whorl. Aperture with a deep angular sinus culminating at the periphery in a long narrow slit; lips thick.

**Dimensions.** Holotype (F78343) MD 2.3 mm, TS 1.8 mm

**Types.** Holotype (F78343) and 10 paratypes (F78530).

**Type locality.** About 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of the Namoi Formation.

**Additional material.** 3 specimens from 'Marohn' (Locality 28).

**Geographic distribution.** From Swains Gully to 'Marohn'.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Derived from the Latin *carina* meaning carinate; referring to the spiral ridge at the periphery.

**Remarks.** This is a relatively rare species, and is characterised by a smooth biconvex shell with a long slit and peripheral keel. The specimens are similar to the type species *Cymbularia galeata* Koken in having a smooth convolute spire with a long narrow slit, but differs in that *C. galeata* has an asymmetrical adult shell and in lacking a keel on the periphery.

*Bellerophon* Montfort, 1808

**Australian Carboniferous species.** *Bellerophon* (*Bellerophon*) *kyndalynensis* n.sp., from 'Kyndalyn'; *Bellerophon* (*Bellerophon*) *swainsensis* n.sp., from Swains Gully.

*Bellerophon* (*Bellerophon*) *kyndalynensis* n.sp.

Pl. 1 figs 9-12

**Description.** Shell minute, subglobular, isostrophic, anomphalous. Protoconch concealed, seemingly minute, planispiral. Teleoconch with whorls moderately involute and with maximum diameter of whorl less than the height of spire; ornament consisting of regularly interspaced and curved transverse costae and wide selenizone marked by curved transverse lunulae, almost the same number as transverse costae. Aperture broadly crescentic with lips without flare anteriorly or laterally, but flaring somewhat backward in the umbilical region; parietal inductura covering a quarter of the last whorl with thickening in the umbilical region.

Dimensions.	MD	TS
Holotype (F78348)	1.2 mm	1.2 mm
Paratypes (F78349a)	1.2	1.4
(F78349b)	1.5	—

**Types.** Holotype (F78348) and 2 figured paratypes (F78349). There are 22 unfigured additional specimens (F78350) from the type locality.

**Type locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW (Locality 24).

**Stratigraphic position.** Base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle or late Viséan.

**Etymology.** Referring to the geographical name of 'Kyndalyn' homestead, Somerton, NSW.

**Remarks.** This species resembles *Bellerophon* (*Bellerophon*) *swainsensis* n.sp. in ornament, but differs in having a much smaller shell with wider selenizone.

*Bellerophon* (*Bellerophon*) *swainsensis* n.sp.

Pl. 1 figs 5-8

**Description.** Shell small, subglobular, isostrophic, anomphalous. Protoconch concealed, seemingly minute, planispiral. Teleoconch whorls involute and with largest diameter of whorl slightly less than height of spire; ornament consisting of closely spaced transverse costae and narrow selenizone; transverse costae curved back into selenizone; selenizone marked by closely spaced short lunulae. Aperture broadly crescentic, lips without flare anteriorly or laterally, but flaring somewhat backward in the umbilical region; parietal inductura covering a quarter of the last whorl, with thickening in the umbilical region.

Dimensions.	MD	TS
Holotype (F78344)	5.7 mm	5.4 mm
Paratypes (F78346a)	5.3	5.6
(F78345)	6.0	6.4
(F78346b)	4.0	6.4

**Types.** Holotype (F78344) and 3 figured paratypes (F78345-6). There are 20 unfigured additional specimens (F78347) from the type locality.

**Type locality.** About 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of the Namoi Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle Tournaisian.

**Etymology.** Referring to the geographical name of Swains Gully, Babbins Lane, NSW.

**Remarks.** This species resembles *Bellerophon* (*Bellerophon*) *kyndalynensis* n.sp. in shell shape, but differs in having a much larger and globular form. It has a far narrower selenizone than *Bellerophon* (*Bellerophon*) *kyndalynensis*.

**Knightitinae** Knight, 1956*Knightites* Moore, 1941*Retispira* Knight, 1945

**Australian Carboniferous species.** *Knightites* (*Retispira*) *culleni* Campbell & Engel, 1963, from 'Rangari'; *Knightites* (*Retispira*) *multilirata* n.sp., from Swains Gully; *Knightites* (*Retispira*) *triangularis* n.sp., from Swains Gully.

***Knightites* (*Retispira*) *culleni* Campbell & Engel**

*Knightites* (*Retispira*) *culleni* Campbell & Engel, 1963: 89, pl. 6 figs 27-33

*Knightites* (*Retispira*) *culleni* Campbell & Engel.-Yoo, 1988: 239.

**Types.** The types have been transferred from the University of New England (UNE F7434, 7435) to the Australian Museum, Sydney.

**Additional material.** 11 specimens from Swains Gully, 21 from 'Marohn' (Locality 28) and 13 from Glenbawn (Localities 30 and 31).

**Stratigraphic position.** Lower part of the Namaoi Formation.

**Geological age.** Middle to late Tournaisian.

***Knightites* (*Retispira*) *multilirata* n.sp.**

Pl. 2 figs 4-7

**Description.** Shell small, isostrophic, widely phaneromphalous. Protoconch concealed. Teleoconch with whorl profile depressed, involute, broadly rounded across dorsum but becoming more sharply rounded laterally, then turning into a wide umbilicus; ornament reticulate, consisting of a large number of fine, sharp spiral and transverse lirae with small nodes developed at intersections; selenizone moderately wide, flush with the shell surface, ornamented by 4 central spiral lirae flanked with 2 weaker spiral lirae on both sides; curved lunulae numbering twice the transverse lirae; shell consisting of 2 layers. Aperture broadly crescentic; lips thickened, flared; slit probably obscured by thickening; parietal inductura thickened for almost a half of a volution.

Dimensions.	MD	TS
Holotype (F78353)	5.2 mm	7.0 mm
Paratypes (F78354)	5.3	6.1
(F78355)	6.3	—

**Types.** Holotype (F78353) and 2 figured paratypes (F78354-5).

**Type locality.** About 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130

m above the base of the Namaoi Formation.

**Additional material.** 2 specimens from the type locality.

**Geographic distribution.** Swains Gully.

**Geological age.** Middle Tournaisian.

**Etymology.** Referring to the multiple lirae of the shell.

**Remarks.** This species differs from *Knightites* (*R.*) *culleni* Campbell & Engel and *Knightites* (*R.*) *triangularis* n.sp. by having a wide and deep umbilicus, depressed whorls and neat reticulate ornamentation.

***Knightites* (*Retispira*) *triangularis* n.sp.**

Pl. 2 figs 1-3

**Description.** Shell small, isostrophic with fan-like form, narrowly phaneromphalous; umbilicus partly obscured in lateral view by a flap-like extension from the parietal inductura. Protoconch concealed, seemingly minute planispiral. Teleoconch with whorls involute and with maximum diameter of whorl less than height of spire; ornament dominated by coarse spiral costae modified by weak transverse lirae with pustules formed at their intersection; spiral costae, about 18-20 in the last whorl, with 1 or 2 weaker spiral costae between the coarse costae; transverse lirae less prominent, but regularly spaced; side of selenizone raised, ornamented by 8 to 9 closely spaced spiral lirae and curved lunulae; shell consisting of 2 layers, the inner layer retaining the same ornamentation as the outer layer, but weaker. Aperture broad, crescentic, only slightly flared at the side; slit short; parietal inductura moderately thickened, approximately one quarter of a volution.

Dimensions.	MD	TS
Holotype (F78351)	7.3 mm	8.6 mm
Paratype (F78352)	6.4	7.1

**Types.** Holotype (F78351) and 1 figured paratype (F78352).

**Type locality.** About 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone 130 m above the base of the Namaoi Formation.

**Geographic distribution.** Swains Gully.

**Geological age.** Middle Tournaisian.

**Etymology.** Referring to the triangular shape in the apertural view.

**Remarks.** This species resembles *Knightites* (*Retispira*) *culleni* Campbell & Engel and *Knightites* (*R.*) *multilirata* n.sp. in having reticulate shell ornamentation, but differs from the former by having a triangular shell shape and coarser ornamentation, and from the latter in having a narrow umbilicus and raised selenizone. *Knightites* (*Retispira*) *triangularis* n.sp. is characterised by coarse wave-like spiral costae with raised wide selenizone whereas *K. (R.) multilirata* has net-like ornament with flat selenizone.



'Archaeogastropoda' Theile, 1925

Euomphaloidea de Koninck, 1881

Onychochilidae Koken, 1925

*Onychochilus* Lindstrom, 1884

**Australian Carboniferous species.** *Onychochilus minutissimus* Yoo, 1988.

*Onychochilus minutissimus* Yoo

*Onychochilus minutissimus* Yoo, 1988: 240, figs 12-14.

**Additional material.** 3 specimens (F78356).

**Remarks.** This species is extremely rare and small in size; a total of seven specimens have been recovered from the type locality, including four specimens in previous investigations (Yoo, 1988). The shells exhibit perfectly balanced adult forms with a sharp boundary between protoconch and teleoconch. This species differs from the type species *O. physa* Lindstrom in being much smaller in size and in lacking ornamentation.

Euomphalidae de Koninck, 1881

*Serpulospira* Cossmann, 1916

**Australian Carboniferous species.** '*Serpulospira* scalariformis' n.sp., from 'Marohn'.

'*Serpulospira* scalariformis' n.sp.

Pl. 2 figs 8-10, Pl. 3 figs 1-5

**Description.** Shell minute, openly coiled. Protoconch bulbous, smooth, curved; margin with teleoconch sharp and distinct. Teleoconch openly coiled, in early whorls with asymmetric spire tending to be symmetric with contact between spires in later whorls; nearly smooth but growth lines distinct throughout, aperture rounded.

Dimensions.	MD	DA
Holotype (F78360)	2.3 mm	0.8 mm
Paratypes (F78357)	2.8	1.0
(F78359)	2.1	0.6
(F78361)	2.9	—
(F78362)	1.3	0.3
(F78358a)	1.4	0.4
(F78358b)	1.3	0.4

**Types.** Holotype (F78360) and 6 figured paratypes (F78357-9, F78361-2). There are 48 unfigured additional specimens (F78390) from the type locality.

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper

part of the Dangarfield Formation.

**Additional material.** 10 specimens from Oxley Highway (Locality 22-2), 3 from south-east of 'Rangari' (Locality 18) and 2 from Glenbawn (Locality 30).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Referring to disjunct whorls.

**Remarks.** The bulbous and smooth protoconch of '*Serpulospira* scalariformis' n.sp. is similar to that of hyoliths. The difference is that the protoconch of this species is curved. The nature of spire and growth lines on the teleoconch suggest that the species could be referred to the macluritoidean gastropods proposed by Linsley (1978a). The species is tentatively placed in the Euomphaloidea, but that is considered problematic by Bandel (personal communication).

*Straparollus* de Montfort, 1810

**Australian Carboniferous species.** *Straparollus australis* Maxwell, 1961, between Splinter Creek and Mount Cannindah, Qld; *Straparollus brevis* n.sp., from 'Kyndalyn'; *Straparollus davidi* Dun & Benson, 1920, from Carroll.

*Straparollus brevis* n.sp.

Pl. 3 figs 6-8

**Description.** Shell very small, low-spined trochiform, widely phaneromphous. Protoconch of 5 or 6 smooth whorls with a sharp demarcation between the protoconch and teleoconch. Teleoconch of 2½ smooth and rounded whorls; whorl profile well arched between sutures; with broadly rounded revolving shoulder on its upper surface and slight flattening above; suture moderately deep; ornamentation of fine growth lines; base and umbilical surface strongly rounded. Aperture almost circular; parietal inductura thin; columellar lip thin, arcuate; outer lip with shallow sinus close to the upper suture, swinging forward below sinus and then rounding backward to cross the lower face and the base with a slight backward obliquity, becoming vertical on the umbilical face.

Dimensions.	H	W	PA	NW
Holotype (F78363)	2.2 mm	1.2 mm	150°	—
Paratypes (F78364a)	1.9	—	—	3¼
(F78364b)	2.3	1.4	145	5

**Types.** Holotype (F78363) and 2 figured paratypes (F78364). There are 20 unfigured additional specimens (F78365) from the type locality.

**Type locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW.

**Stratigraphic position.** From base of oolitic limestone, in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle or late Viséan.



**Etymology.** Derived from the Latin word *brevis* meaning short; referring to the low spire of the shell.

**Remarks.** This is smaller in size than any other species referred to subgenus *Straparollus*. This species has a larger pleural angle (145-150°) than in *S. davidi* Dun & Benson (120-130°) and the type species *Straparollus dionysii* Montfort (pleural angle about 80°) from Belgium. Another European species *Straparollus levigatus* (Leveille) and *Straparollus planorbiformis* de Koninck are rather flatly coiled.

*Straparollus davidi* Dun & Benson

**Description.** Campbell & Engel (1963:95).

**Type.** Lectotype (F78391).

**Geographic distribution.** From 'Rangari' south to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Remarks.** This is a very common species of relatively large size. The single specimen (F1773, Geological and Mining Museum, Sydney) described by Dun & Benson (1920) from Carroll is missing (Campbell & Engel, 1963). The specimen here chosen as lectotype is rather young and well preserved. It was recovered from the lower part of the Namoi Formation in Swains Gully, where the species occurs abundantly (Locality 25). The species has a short and smooth protoconch, and is planispiral in early whorls.

*Pleurotomarioidea* Swainson, 1940

*Sinuopeidae* Wenz, 1938

*Platyschismatinae* Knight, 1956

*Platyschisma* M'Coy, 1844

**Australian Carboniferous species.** *Platyschisma lingua* n.sp., from 'Rangari'; *Platyschisma vitrea* n.sp., from 'Marohn'.

**Remarks.** The Early Permian species *Platyschisma allandalensis* Mitchell (1922) and the form referred to *Platyschisma oculus* Sowerby by de Koninck (1876) are large in size. The width of *P. allandalensis* is 105 mm. The original figures of *P. allandalensis* does not show the detail of the shell, and its exact locality is not known. Comparison of *P. allandalensis* with the type species, *Platyschisma helicoides* Sowerby, suggests that *P. allandalensis* is better referred to *Keeneia* of Etheridge (1902).

*Platyschisma lingua* n.sp.

Pl. 4 figs 1-3

**Description.** Shell of about 5 whorls, very small, low spired, naticiform, thin, with spiral ornament,

phaneromphalous. Protoconch simple, sharply pointed. Teleoconch with whorls increasing rapidly in size with whorl profile inflated and sutures moderately deep; ornamentation of closely spaced fine spiral lirae; base rounded, pseudoselenizone narrow above periphery; aperture with columellar lip slightly thickened and sinuous; parietal inductura wanting; outer lip with a moderately deep and narrow sinus culminating in a small and narrow slit or notch; anterior margin of the lip with prominent tongue-like siphonal extension.

Dimensions.	H	W	PA	NW
Holotype (F78369)	2.4 mm	2.7 mm	135°	4½
Paratypes (F78370)	2.8	3.1	130	5
(F78371)	4.9	5.0	125	5

**Types.** Holotype (F78369) and 2 figured paratypes (F78370 and F78371).

**Type locality.** The holotype is from 4 km south-east of 'Rangari' homestead on the Gunnedah-Barraba roadside, 34 km north-east of Gunnedah, NSW (Locality 18); 1 paratype is from Glenbawn (Locality 30) and the other paratype is from Swains Gully (Locality 25).

**Stratigraphic position.** In bioclastic limestone from the middle limestone lens in the Tulcumba Sandstone, from the lower part of the Namoi formation, and from the upper part of the Dangarfield Formation.

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Derived from the Latin *lingua* meaning tongue, referring to the shape of the anterior siphonal extension.

**Remarks.** This species is characterised by a large aperture and a long tongue-like anterior siphonal extension. It resembles *Platyschisma vitrea* n.sp. in having a low spire and in being smaller in size, but differs in having fine spiral lirae.

*Platyschisma vitrea* n.sp.

Pl. 3 figs 9-12

**Description.** Shell of 4½ whorls, very small, low spired, naticiform, thin, shelled, with glossy surface, broadly phaneromphalous. Protoconch simple, smooth, rather flatly coiled, with no defined boundary between protoconch and teleoconch. Teleoconch whorls increasing in size gradually, whorl profile rounded; sutures moderately deep; surface glossy smooth with faint growth lines; base rounded but angled towards umbilicus; numerous revolving lirae and conspicuous growth lines within and near umbilicus; selenizone narrow just above periphery; aperture subcircular with columellar lip thin and reflexed; parietal inductura wanting, outer lip thin with a strongly developed sinus culminating just below periphery without generating a slit.

Dimensions.	H	W	NW
Holotype (F78366)	— mm	2.5 mm	4½
Paratypes (F78367a)	—	2.1	—
(F78367b)	1.0	1.3	—

**Types.** Holotype (F78366) and 2 figured paratypes

(F78367). There are 32 unfigured additional specimens (F78368) from the type locality.

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Late Tournaisian.

**Etymology.** Derived from the Latin *vitrea* meaning glossy, referring to the glossy surface of shell.

**Remarks.** This species is similar to *Straparollus brevis* n.sp. in having a low spired shell with a large umbilicus, but is very different in the shape of aperture and shell thickness. *Platyschisma vitrea* is characterised by having a thin glossy shell, suggesting that it may have been an algal dweller.

**Raphistomatidae** Koken, 1896

**Liospirinae** Knight, 1956

***Angyomphalus*** Cossmann, 1916

**Australian Carboniferous species.** *Angyomphalus depressus* Campbell & Engel (1963), from 'Rangari'; *Angyomphalus radianodosa* n.sp.

***Angyomphalus radianodosa* n.sp.**

Pl. 4 figs 4-10

**Description.** Shell very small low-spired lenticular, with 4½ whorls, phaneromphalous. Protoconch seemingly simple, smooth, without sharp boundary between protoconch and teleoconch; suture shallow; upper whorl face sloping gently toward the periphery and decorated by narrow radiating nodes which are slightly sigmoidal just below the suture; growth lines extending beyond the nodes, prosocline above the peripheral selenizone, but faint below the selenizone, swinging forward for a short distance and then backward into the umbilicus; columellar lip thin next to the parietal wall but with a thick subtriangular section at the circumumbilical funicle, outer lip thin, sharply angulated at periphery, size of slit and lunulae unknown.

Dimensions.		H	W
Holotype	(F78372)	2.5 mm	3.9 mm
Paratypes	(F78376a)	—	3.8
	(F78373)	2.5	3.9
	(F78376b)	—	3.4
	(F78375)	—	3.2

**Types.** Holotype (F78372) and 6 figures paratypes (F78373-6). There are 42 unfigured additional specimens (F78377) from the type locality.

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Additional material.** 25 from Swains Gully (Locality 25), 6 from south-east of 'Rangari' (Locality 18) and 6 from Glenbawn (Locality 31).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Derived from the Latin *radial* meaning radial, and *nodosus* meaning nodose; referring to the radial nodes below the sutures.

**Remarks.** This form differs from the only described Australian species, *Angyomphalus depressa* Campbell & Engel in that the latter has a low spired shell with more acute periphery and more closely spaced and longer nodes just below the suture. It resembles the Belgian type species *Angyomphalus radians* (de Koninck, 1881) in shell character but differs in being much smaller.

**Eotomariidae** Wenz, 1938

**Eotomariinae** Wenz, 1938

***Eotomaria*** Ulrich & Scofield, 1897

**Australian Carboniferous species.** *Eotomaria umbilicata* n.sp., from 'Marohn'.

**Remarks.** *Eotomaria* resembles somewhat *Mourlonia* de Koninck (1883), but differs in that *Mourlonia* has a taller, more globular shell with minute umbilicus. *Eotomaria* was previously recorded as having the range from Ordovician to Silurian. If it is correctly placed, this record may extend to early Carboniferous.

***Eotomaria umbilicata* n.sp.**

Pl. 5 figs 1-3

**Description.** Shell of about 4 whorls, very small, low spired, rotelliform, and widely phaneromphalous. Protoconch simple, first 1½ whorls smooth, the remainder with faint reticulate ornament, with spiral and collabral cords appearing on the third whorl. Teleoconch with whorls increasing in size rapidly; whorl profile inflated with area above selenizone rather flat; sutures moderately deep; ornamentation of strong regularly spaced collabral cords with lighter spiral threads, collabral cords orthocline below suture, but curved backward towards upper margin of selenizone; cords more finely spaced below selenizone with strong sinus extended to the base. Selenizone wide, bordered by raised spiral thread; lower margin of selenizone on whorl periphery slightly concave, ornamented with curved lunulae. Aperture simple, inner lip thin, arcuate; outer lip with a deep sinus culminating in a moderately deep slit above periphery.

Dimensions.	H	W	PA	NW
Holotype (F78379)	1.6 mm	2.2 mm	125°	4
Paratypes (F78380a)	—	2.5	—	—
(F78380b)	—	1.9	—	4

**Types.** Holotype (F78379) and 2 figured paratypes (F78380). There are 42 unfigured additional specimens (F78381) from the type locality.

**Type locality.** 150 m west of 'Marohn', homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Additional material.** 12 specimens from various horizons of the Dangarfield Formation, east of Glenbawn Dam (Localities 29-31).

**Geographic distribution.** Glenbawn area.

**Geological age.** Late Tournaisian.

**Etymology.** Referring to umbilicus.

**Remarks.** This species is characterised by a low spired shell with strong sinuous collabral cords and an exceptionally wide umbilicus. This form resembles the type species *Eotomaria canalifera* Ulrich in Ulrich & Scofield from Tennessee, in having a coeloconoidal, sublenticular shell with deep sinus and selenizone above the periphery, but differs from in having round whorl profile and round aperture. This is different from any known species of the Australian euomphaloideans.

#### *Glabrocingulum* Thomas, 1940

**Australian Carboniferous species.** *Glabrocingulum obesum* Yoo, 1988, from 'Marohn'; *Glabrocingulum ornatum* (Dun & Benson), 1920, from south of Somerton; *Glabrocingulum pustulum* n.sp., from Swains Gully; *Glabrocingulum* sp. (in this study), from 'Marohn'.

#### *Glabrocingulum obesum* Yoo

Pl. 6 figs 4-10

*Glabrocingulum obesum* Yoo, 1988: 241, figs 33-35.

Dimensions.	H	W	PA
Figured specimens			
(F78394a)	1.5 mm	1mm	98°
(F78394b)	2.3	2.4	100
(F78394c)	2.2	2.5	100
(F78393)	5.0	5.0	80
(F78395)	3.2	2.6	85

**Additional material.** 30 additional specimens of *G. obesum* Yoo, 1988 were recovered from the type locality and east of Glenbawn Dam (Locality 30).

**Remarks.** The figured specimens (Pl. 6 figs 6, 9, 10) appear to be immature. The specimens (Pl. 6 figs 4, 5) have straight whorl profiles with smaller pleural angle, coarser ornamentation and smaller umbilicus, which appears to be relatively mature. This species differs from *Glabrocingulum ornatum* (Dun & Benson) in having smaller and low-spired shell.

#### *Glabrocingulum pustulum* n.sp.

Pl. 7 figs 1-4

**Description.** Shell small, trochiform, with 5 whorls, narrowly phaneromphalous. Protoconch simple, smooth, round. Teleoconch conical, whorl profile round in early whorls becoming rather flat in later whorls with deep suture, about 3½ whorls with broadly subangular periphery; ornamentation of sharp spiral lirae bearing nodes where crossed by prosocline collabral threads; ornamentation below selenizone is weaker. Selenizone narrow and flat to just above periphery, ornamented with curved lunulae, present from third whorl. Aperture with inner lip straight, thickened, slightly extended towards umbilicus, outer lip with gentle labral sinus culminating in a small notch.

Dimensions.	H	W	PA	NW
Holotype (F78397)	5.6 mm	5.5 mm	80°	5
Paratype (F78398)	5	5	85	5½

**Types.** Holotype (F78397), 1 figured paratype (F78398) and 10 paratypes (F78392).

**Type locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of the Namoi Formation.

**Additional material.** 8 specimens from Oxley Highway (Locality 22-2), 2 from north-east of 'Rangari' (Locality 15), 2 from 'Marohn' (Locality 28), and 2 from Glenbawn (Localities 30 and 31).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Referring to the nodes covering the shell surface.

**Remarks.** This species differs from *G. obesum* Yoo in having a conical shell with a narrower umbilicus, and a different pattern of the selenizone ornamentation. *Glabrocingulum* sp. has a low spired shell with round and inflated whorl profile, while *G. pustulum* n.sp. has rather flat whorl profile with subangular periphery.

#### *Glabrocingulum* sp.

Pl. 6 figs 11-12

**Dimensions.** Figured specimen (F78396) H 3.5 mm, W 3.7 mm

**Locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** 130 m above the base of the Namoi Formation.

#### *Campbellospira* n.gen.

**Type species.** *Campbellospira conica* n.sp.

**Definition.** Turbiniform, low-spired, conical shell; moderately phaneromphalous; ornamented by transverse cords and spiral lirae, most prominent near upper suture; selenizone concave between a pair of conspicuous cords just above periphery.

**Geological age.** Middle Tournaisian.

**Etymology.** This genus is named for Professor K.S.W. Campbell of the Australian National University for his contribution to the study of eastern Australian Carboniferous geology and palaeontology.

**Remarks.** This genus is similar to other pleurotomarioideans in general, but is different in having a planktotrophic protoconch. Specimens belonging to this genus are very common at the type locality.

**Australian Carboniferous species.** *Campbellospira conica* n.sp., *Campbellospira* sp. A, B and C; all from Swains Gully.

*Campbellospira conica* n.sp.

Pl. 5 figs 4-7

**Description.** Very small, conically spired turbiniform shell of  $5\frac{1}{2}$  whorls, phaneromphalous. Protoconch simple, with 2 whorls with faint growth lines and with distinct varix. Teleoconch with conical spire subtending an angle of  $85-90^\circ$ ,  $3\frac{1}{2}$  whorls with sutures incised; ornamentation of strong collabral cords and faint spiral threads, with approximately 30 collabral cords in the final whorl; cords orthocline above selenizone and shallow sinus below selenizone extending to base. Selenizone moderately wide, bordered by spiral ridges high on the whorl, slightly concave, ornamented with fine spiral threads. Aperture with thickened arcuate inner lip; outer lip with a broad, shallow sinus culminating in a broad, seemingly shallow slit above the periphery.

Dimensions.	H	W	PA	NW
Holotype (F78382)	4.3 mm	4.2 mm	$90^\circ$	$5\frac{1}{2}$
Paratypes (F78384)	3.8	3.5	88	$5\frac{1}{2}$
(F78383)	3.6	—	90	5

**Type.** Holotype (F78382) and 2 figured paratypes (F78383-4). There are 65 unfigured additional specimens (F78378) from the type locality.

**Type locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of the Namoi Formation.

**Additional material.** 1 specimen from south-east of 'Rangari' (Locality 18).

**Geographic distribution.** 'Rangari' to Swains Gully.

**Geological age.** Middle Tournaisian.

**Etymology.** Referring to the conical shell shape.

**Remarks.** *Campbellospira conica* n.sp. differs from other species of *Campbellospira* in many respects: *Campbellospira* sp. A has a low spire with convex whorl profile, more closely spaced collabral cords above the selenizone and a smooth surface except for growth lines below selenizone. *Campbellospira* sp. B has a relatively

high spire with canaliculate profile, and prominent spiral cords below the selenizone; *Campbellospira* sp. C is a low-spired biconvex lenticular form with a larger pleural angle ( $117^\circ$ ).

*Campbellospira* sp. A

Pl. 5 figs 8-10

Dimensions.	H	W	PA
Figured specimens			
(F78385)	3.4 mm	3.8 mm	$90^\circ$
(F78386)	2.7	3.0	95

**Locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** 130 m above the base of the Namoi Formation.

*Campbellospira* sp. B

Pl. 5 figs 11-12

**Dimensions.** Figured specimen H 2.7 mm, PA  $75^\circ$ , NW  $5\frac{1}{2}$ .

**Locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** 130 m above the base of the Namoi Formation.

*Campbellospira* sp. C

Pl. 6 figs 1-3

Dimensions.	H	W	PA
Figured specimens			
(F78388)	3.0 mm	3.1 mm	$117^\circ$
(F78389)	3.1	3.5	120

**Locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** 130 m above the base of the Namoi, Formation.

Agnesiinae Knight, 1956

*Hesperiella* Holzapfel, 1889

**Australian Carboniferous species.** *Hesperiella elongata* n.sp., from 'Rangari'; *Hesperiella planorbis* n.sp., from 'Marohn'; *Hesperiella robertsi* Yoo, 1988, from 'Marohn'.

**Remarks.** The structure of the submerged protoconch of *Hesperiella* has been discussed by Knight (1941), Batten (1966) and Yoo (1988). It is almost certain that this genus has a hyperstrophically coiled dextral shell. *Hesperiella* has a narrow selenizone seen only in the final whorl. The slit is observed in the juvenile specimens (Pl. 7 figs 10-12), although it is not obvious in the adult shells.

*Hesperiella elongata* n.sp.

Pl. 7 figs 5-7

**Description.** Shell very small, rather high spired, sinistral, anomphalous or hemiomphalous. Protoconch coiling inward and hidden by later whorls, apex a funnel-like hole. Teleoconch with whorl profile rather straight; collabral costae widely spaced, opisthocline, with about 40 cords in the final whorl. Selenizone narrow, concave, smooth, adjacent to lower suture, seen only in the final whorl. Aperture subangular.

Dimensions.	H	W	PA	NW
Holotype (F78399)	4.1 mm	3.7 mm	50°	4½
Paratype (F78400)	2.5	2.7	—	—

**Types.** Holotype (F78399) and 3 paratypes (F78400, F78405).

**Type locality.** 4 km south-east of 'Rangari' homestead, on the Gunnedah-Barraba roadside, 34 km north-east of Gunnedah, NSW (Locality 18).

**Stratigraphic position.** In bioclastic limestone, the middle limestone lens in the Tulcumba Sandstone.

**Additional material.** 1 specimen each from north of 'Rangari' (Locality 14), north-east of 'Rangari' (Locality 15) and Glenbawn (Locality 29).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Derived from the Latin *elongatus* meaning elongate, referring to the tall spire of shell.

**Remarks.** This species is characterised by a tall-spined shell with a rather flat whorl profile, which is very different from any other *Hesperiella* species.

*Hesperiella planorbis* n.sp.

Pl. 7 figs 9-13

**Description.** Shell very small, low spired, sinistral, broadly phaneromphalous. Protoconch coiling inward and hidden by later whorls, but seen in umbilicus, smooth, one and one eighth whorls, apex bulbous. Teleoconch with first 1? whorls planispiral, becoming ultradextral, growth lines in early whorls but gradually becoming stronger; collabral lirae above selenizone, opisthocline below selenizone; fine collabral thread extended to umbilicus. Selenizone present from early teleoconch whorl, narrow on periphery. Aperture round; inner and parietal lips thin, outer lip thickened; slit is seen in juvenile shells.

Dimensions.	H	W
Holotype (F78402)	1.7 mm	2.6 mm
Paratype (F78403)	0.8	1.3

**Types.** Holotype (F78402) and 3 figured paratypes (F78403). There are 15 unfigured additional specimens (F78404) from the type locality.

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, in upper part of the Dangarfield Formation.

**Additional material.** 1 specimen from Glenbawn (Locality 31) and 1 from Swains Gully (Locality 25).

**Geographic distribution.** Swains Gully to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Referring to the planispirally coiled early stage of development of the shell.

**Remarks.** This species differs from other species of this genus in having a low-spined shell, a very wide umbilicus, and a flattened selenizone. The protoconch and nepionic whorls are planispiral and the early ontogenetic pattern of development is seen through the umbilicus. Two figured paratypes are juveniles.

*Hesperiella robertsi* Yoo

Pl. 7 fig. 8

*Hesperiella robertsi* Yoo, 1988: 241, figs 36-41.

**Additional material.** 34 specimens from the type locality, 16 from various horizons at Glenbawn (Localities 29-31) and 8 from south-east of 'Rangari' (Locality 18). 1 from 'Lorrina' (Locality 23).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Remarks.** This species is abundant at Glenbawn, and occurs commonly at 'Rangari', but has not been recovered at Swains Gully (Locality 25). A single specimen recovered at 'Lorrina', from a stratigraphically higher horizon in the Namoi Formation, is here temporarily assigned to this species. Figured specimen (Pl. 7 fig. 8) is an immature form.

*Agnesia* de Koninck, 1883

**Australian Carboniferous species.** *Agnesia reticulata* n.sp., from Swains Gully.

**Remarks.** This is the first record of *Agnesia* in Australia. *Agnesia* resembles *Hesperiella* in having a sinistrally coiled shell, with an inturned protoconch, and moderately wide umbilicus, but differs in having a reticulate ornamentation and the narrow, deep peculiar selenizone. The protoconch of *Agnesia* has not yet been observed, but because of the inward coiling, as seen in *Hesperiella*, it is assumed that *Agnesia* has a hyperstrophically coiled dextral shell.

*Agnesia reticulata* n.sp.

Pl. 8 figs 1-3

**Description.** Shell medium, trochiform, sinistral, moderately phaneromphalous. Protoconch coiling inward and hidden by later whorls, apex a funnel-like hole. Teleoconch conical with sunken top, whorl profile gently arched between sutures, rather deep, base gently convex, ornamentation of opisthocline collabral lirae and weaker spiral threads making small nodes in intersections. Selenizone relatively narrow; lower margin of selenizone on sutures with a narrower and deeper channel in the middle of the elevated selenizone; regularly spaced lunulae in the deeper channel and regularly spaced inclined streaks in outer selenizone. Aperture subcircular with inner lip thin, arcuate, deflected towards umbilicus; outer lip opisthocline from the upper suture, slit seemingly very narrow; parietal indurata lacking.

Dimensions.	H	W	PA	NW
Holotype (F78406)	10 mm	7.1 mm	70°	4½
Paratype (F78410)	6.3	5.2	72	4

**Types.** Holotype (F78406) and 3 paratypes (F78410, F78416).

**Type locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of the Namoi Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle Tournaisian.

**Etymology.** Referring to the network of obliquely intersecting linear ridges.

**Remarks.** The shell consists of two distinct layers. Of interest is the mark of the deeper channel and the lunulae remaining on the inner shell layer.

## Neilsoniinae Knight, 1956

*Peruvispira* J. Chronic, 1949

**Australian Carboniferous species.** *Peruvispira gundyensis* Yoo, 1988, from 'Marohn'; *Peruvispira kempseyensis* Campbell, 1962, from Sherwood, 17 km west-north-west of Kempsey; *Peruvispira kuttungensis* Campbell 1961, from the Booral Formation, south-east of the Gloucester Trough.

*Peruvispira gundyensis* Yoo

Pl. 8 figs 4-8

*Peruvispira gundyensis* Yoo, 1988: 242, figs 29-32.

Dimensions.	H	W	PA	NW
Figured specimens				
(F78408)	4.1 mm	3.4 mm	67°	6½
(F78409a)	2.8	2.1	70	5½

(F78407)	2.3	2.1	71	5½
(F78409b)	2.9	2.4	68	5½

**Additional material.** 57 specimens from 'Marohn' (Locality 28), 23 from south-east of 'Rangari' (Locality 18), 15 from Swains Gully (Locality 25), 61 from various horizons at Glenbawn (Localities 29-32).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Early to late Tournaisian.

**Remarks.** The difference of this species from *Peruvispira kempseyensis* Campbell, 1962 and *Peruvispira kuttungensis* Campbell, 1961 has already been discussed (Yoo, 1988). This species is very common between 'Rangari' and Glenbawn with some minor variations. The ontogenetic development of this species is well displayed in Plate 8 figure 6.

## Lophospiridae Wenz, 1938

## Ruedemanninae Knight, 1956

*Ruedemannia* Foerste, 1914

**Australian Carboniferous species.** *Ruedemannia bembexiformis* Campbell & Engel, 1963, from Rangari; *Ruedemannia* sp. (in this study), from Swains Gully.

**Remarks.** As Knight *et al.* (1960) suggested, Carboniferous *Ruedemannia* appears to converge in various characters on *Worthenia*. In this investigation, specimens possessing conspicuous collabral cords are tentatively referred to *Ruedemannia*.

*Ruedemannia* sp.

Pl. 8 figs 9-10, Pl. 9 figs 1-4

**Description.** Shell medium, turbiniform, moderately phaneromphalous with convex crenulated selenizone in the middle of whorl; protoconch seemingly smooth, collabral threads in the nepionic whorls; 1 spiral cord above and 2 below selenizone; collabral cords sharp, regularly spaced; outer lip with a wide shallow sinus culminating at the periphery in a short slit.

Dimensions.	H	W
Figured specimens (F78411)	9.7 mm	7.1 mm
(F78414)	6.3	4.4
(F78417)	5.2	4.4
(F78418)	3.8	3.1

**Locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** 130 m above the base of the Namoi Formation.

**Additional material.** 4 specimens from the same locality.

**Geographic distribution.** Above locality only.

**Geological age.** Middle Tournaisian.

**Remarks.** *Ruedemannia* sp. differs from *R. bembexiformis* Campbell & Engel in having spiral cords on the base and a minute umbilicus.



*Worthenia* de Koninck, 1883

**Australian Carboniferous species.** *Worthenia*(?) *canaliculata* Etheridge, 1907, from Carrol; *Worthenia crenilunula* n.sp., from Swains Gully; *Worthenia* sp. Campbell & Engel, 1963, from 'Rangari'; *Worthenia* sp. (in this study), from Swains Gully.

*Worthenia crenilunula* n.sp.

Pl. 8 figs 11-14, Pl. 9 figs 5-8

**Description.** Shell small, turbiniform, heavily ornamented, narrowly phaneromphalous to anomphalous. Protoconch with first whorl seemingly smooth. Teleoconch in 2 distinct layers, the outer layer thin; approximately 5 whorls; suture shallow, whorl profile with strong angulations; selenizone most prominently protruded with upper and lower spiral cords falling just below and above suture, more obtuse; transverse lirae sharp, closely spaced, forming sharp points at the intersection with the protruded selenizone; base with several spiral cords. Selenizone moderately wide, convex, ornamented by the same number of pointed lunulae, as collabral lirae. Aperture with inner lip thin, more or less straight, outer lip with a v-shaped sinus culminating at the angulation in a short slit giving rise to a convex, ornamented selenizone.

Dimensions.	H	W	PA	NW
Holotype (F78419)	6.4 mm	4.9 mm	65°	5½
Paratypes (F78413a)	4.5	3.6	63	5½
(F78415)	4.9	3.9	63	6
(F78413b)	6.6	4.4	60	6½

**Types.** Holotype (F78419) and 3 figured paratypes (F78413, F78415). There are 25 unfigured additional specimens (F78412) from the type locality.

**Type locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of the Namoi Formation.

**Additional material.** 7 specimens from south-east of 'Rangari' (Locality 18) and 1 from Glenbawn (Locality 30).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Referring to the prominent crenate lunulae of the selenizone.

**Remarks.** This species resembles *Ruedemannia* sp. and *Worthenia* sp. (both in this study), but differs from the former in having more conspicuous spiral cords on the whorls including the base, and from the latter in having a taller shell and more narrowly phaneromphalous.

*Worthenia* sp.

Pl. 9 figs 9-11

Dimensions.	H	W
Figured specimens (F78420)	2.1 mm	1.8 mm
(F78421)	1.8	1.7

**Locality.** 1.8 km east from the southern end of Glenbawn Dam, 13 km north-east of Aberdeen, NSW (Localities 30 and 31).

**Stratigraphic position.** In the upper part of the Dangarfield Formation.

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Late Tournaisian.

## Phymatopleuridae Batten, 1956

*Borestus* Thomas, 1940

**Australian Carboniferous species.** *Borestus costatus* Yoo, 1988, from 'Marohn'.

*Borestus costatus* Yoo

Pl. 10 figs 1-5

*Borestus costatus* Yoo, 1988: 242, figs 25-28.

Dimensions.	H	W	PA
Figured specimens			
(F78422)	6.6 mm	5.0 mm	60°
(F78423)	2.7	2.1	65
(F78424)	3.9	3.4	75

**Additional material.** 3 specimens from south-east of 'Rangari' (Locality 18), 2 from Swains Gully (Locality 25), 4 from 'Marohn' (Locality 28), 3 from Glenbawn (Locality 31).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Early to late Tournaisian.

## Patelloidea Rafinesque 1815

## Family Uncertain

*Lepetopsis* Whitfield, 1882

**Remarks.** The investigated specimen is a very small juvenile and has a well preserved, seemingly planispiral apex. No muscle scar was observed. The specimen resembles the type species in having a similar shell shape and concentric ornamentation. One small juvenile specimen with an asymmetric spiral apex is noticed. The placement of this specimen to '*Lepetopsis*' is uncertain.



*'Lepetopsis'* sp.

Pl. 10 figs 11-12

**Dimension.** Maximum diameter of figured specimen (F78428) is 1.4 mm.

**Material.** 3 juvenile specimens from 'Marohn' and Glenbawn (Localities 28, 31).

Trochoidea Cox &amp; Knight, 1960

Holopeidae Wenz, 1938

Gyronematinae Knight, 1956

*Araeonema* Knight 1933

**Australian Carboniferous species.** *Araeonema microspirulata* Yoo, 1988, from 'Marohn'.

*Araeonema microspirulata* Yoo

Pl. 13 fig. 12

*Araeonema microspirulata* Yoo, 1988: 243, figs 46-49.

**Dimensions.** Holotype (F61958) H 1.2 mm, W 1.1 mm.

**Additional material.** 73 specimens from 'Marohn' (Locality 28), 2 from Glenbawn (Locality 29) and 1 from 'Lorrina' (Locality 23).

**Geographic distribution.** 'Lorrina' to Glenbawn.

**Geological age.** Late Tournaisian.

**Remarks.** This species has a very thin shell, yet is extremely well preserved. It is one of the most abundant species at the type locality. A single worn specimen recovered from the upper part of the Namoi Formation at 'Lorrina' is tentatively referred to this species.

*Rhabdotocochlis* Knight, 1933

**Australian Carboniferous species.** *Rhabdotocochlis turgida* n.sp., from Glenbawn.

*Rhabdotocochlis turgida* n.sp.

Pl. 11 figs 1-10

**Description.** Shell very small, medium-spined turbiniform, coeloconoid, narrowly phaneromphalous. Protoconch of 1¼ smooth whorls, and a rather flat apex. Teleoconch whorl profile gently arched between sutures, rounded on the final whorl, sutures moderately deep, spiral lirae rising gradually on the second whorl, then becoming gradually stronger; 18 lirae between sutures, shell consisting of two layers. Aperture with straight inner lip thickened, slightly reflexed; outer lip orthocline.

Dimensions.	H	W	PA	NW
Holotype (F62002)	4.9 mm	4.7 mm	90°	4½
Paratypes (F78429a)	5.0	5.2	88	5½
(F78429b)	2.9	2.9	90	4
(F78430)	3.5	3.4	90	4

**Types.** Holotype (F62002) 3 figured paratypes (F78429-30) and 12 unfigured paratypes (F78433).

**Type locality.** 1.8 km east from the southern end of Glenbawn Dam wall, 13 km north-east of Aberdeen, NSW (Locality 30).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Additional material.** 6 specimens from south-east of 'Rangari' (Locality 18), and 10 from various horizons at Glenbawn (Locality 31).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Derived from the Latin *turgidus* meaning swollen, referring to the inflated last whorl.

**Remarks.** *Rhabdotocochlis turgida* n.sp. differs from *Araeonema microspirulata* in having a larger and thicker shell consisting of two layers, and coarser spiral lirae, and from the type species, *Rhabdotocochlis rugata* Knight, in having the more inflated last whorl and finer spiral lirae.

*Gyronema* Ulrich in Ulrich & Scofield, 1897

**Australian Carboniferous species.** *Gyronema nacreformis* n.sp.

*Gyronema nacreformis* n.sp.

Pl. 10 figs 6-10

**Description.** Shell small, moderately high-spined turbiniform, narrowly phaneromphalous. Protoconch simple, seemingly smooth, with a sharp boundary between protoconch and teleoconch. Teleoconch consisting of 2 layers with nacreous lining on inner surface with whorl profile moderately arched, suture moderately deep, first 1¼ whorls smooth with growth lines very faint remainder of teleoconch with spiral lirae, 15 in the final whorl, growth lines obscure. Aperture suboval, with finer lip thin, straight to slightly arcuate, reflexed, anterior end somewhat extended; outer lip thin with a shallow sinus.

Dimensions.	H	W	PA	NW
Holotype (F78425)	5.4 mm	3.6 mm	60°	5
Paratype (F78426)	2.7	2.2	65	4½

**Types.** Holotype (F78425), 1 figured paratype (F78426) and 9 unfigured paratypes (F78427).

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Additional material.** 10 specimens from Swains Gully (Locality 25).

**Geographic distribution.** Swains Gully to 'Marohn'.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Referring to the nacreous internal surface layer of the shell.

**Remarks.** *Gyronema nacreformis* n.sp. is characterised by having a double layered shell with nacreous inner lining, which is commonly seen in Recent species of Trochidae. The shell surface is generally buff in color, but the original nacre is observed on the inner surface of a number of specimens. *Gyronema nacreformis* differs from the type species, *Gyronema subsinuata* (Meek & Worthen), in lacking parietal inductura. The tall, smooth protoconch and absence of selenizone preclude this form from the pleurotomarioidean gastropods.

### Microdomatidae Wenz, 1938

#### *Microdoma* Meek & Worthen, 1867

**Australian Carboniferous species.** *Microdoma angulata* Yoo, 1988, from 'Marohn'.

#### *Microdoma angulata* Yoo

Pl. 11 figs 11-13

*Microdoma angulata* Yoo, 1988: 243, figs 58-60.

Dimensions.	H	W
Figured specimens (F78434a)	3.4 mm	2.2 mm
(F78434b)	2.6	1.4
(F78434c)	3.1	1.9

**Additional material.** 27 specimens from 'Marohn' (Locality 28), 1 from Swains Gully (Locality 25) and 7 from south-east of 'Rangari' (Locality 18).

**Geographic distribution.** 'Rangari' to 'Marohn'.

**Geological age.** Middle to late Tournaisian.

**Remarks.** *Microdoma angulata* Yoo is similar to the European species *Microdoma uniserrata* Batten, but differs in having a large pleural angle and more collabral cords. This species is very different from other European species *Microdoma triserrata* Batten, *Microdoma bicrenulata* de Koninck, as well as North American species *Microdoma conica* Meek & Worthen and *Microdoma ornata* Sayre.

### Neritoidea Rafinesque, 1815

#### Neritopsidae S.A. Miller, 1889

#### *Naticopsis* M'Coy, 1884

**Australian Carboniferous species.** *Naticopsis (Naticopsis) minuta* n.sp., from 'Kyndalyn'; *Naticopsis*

*obliqua* Dun & Benson, 1920: 362, pl. 22 figs 13, 14, from south-east of Babbinsboon, NSW; *Naticopsis (Naticopsis) osbornei* Yoo, 1988: 244, figs 65-66, from 'Marohn'.

**Remarks.** Two *Naticopsis* forms from Carroll and Babbinsboon are referred to the Belgian species *Naticopsis brevispira* (Ryckholt) and *Naticopsis globosa* (Hoeninghaus) by Dun & Benson (1920). However, their identifications cannot be confirmed, as the illustration of these species is too poor, and the figured specimens appear to be lost.

#### *Naticopsis (Naticopsis) minuta* n.sp.

Pl. 14 Figs 9-12

**Description.** Shell minute, globular, neritiform, anomphalous. Protoconch of about 1½ smooth whorls, apex bulbous. Teleoconch of about 2½, convex whorls, suture with whorls adpressed, surface ornamented with fine collabral threads, whorl embracing much of previous whorl. Aperture convex, lenticular in shape; columella lip slightly thickened, arched; inner lip and outer lip thin.

Dimensions.	H	W	PA
Holotype (F78463)	1.1 mm	1.1 mm	130°
Paratype (F78464)	1.2	1.1	130

**Types.** Holotype (F78463) and 1 figured paratype (F78464). There are 50 unfigured additional specimens (F78462) from the type locality.

**Type locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW (Locality 24).

**Stratigraphic position.** In base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle or late Viséan.

**Etymology.** Derived from the Latin *minutus* meaning little, small.

**Remarks.** This is a small shell with a thin callus, commonly occurring in the type locality.

#### *Naticopsis (Naticopsis) osbornei* Yoo

Pl. 14 Figs 1-8

*Naticopsis (Naticopsis) osbornei* Yoo, 1988: 244, figs 65-66.

Dimensions.	H	W	PA	NW
Figured specimens				
(F78457a)	2.8mm	2.4 mm	113°	3½
(F78456)	1.8	2.0	125	3
(F78457b)	2.1	2.3	115	3½
(F78458)	3.9	3.5	124	4
(F78459a)	4.5	3.6	—	—
(F78459b)	6.0	5.6	130	3
(F78460)	3.4	3.3	120	4

**Additional material.** 8 specimens from 'Marohn' (Locality 28) and 1 specimen from Glenbawn (Locality 30).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Remarks.** Fifty specimens recovered between 'Rangari' and Glenbawn show a considerable variability in shell shape, ornamentation and callus rugae. Some forms are elongate while others seem distorted. The shape and size of callus are also variable. Specimens are usually ornamented by collabral striae which are more distinct in the last whorl. Plate 14 figure 6 shows stronger striae developed just below the suture of the last whorl.

*Turbonitella* de Koninck, 1881

*Turbonitella* sp.

Pl. 15 figs 1-2

**Description.** Shell very small, turbiniform, anomphalous. Protoconch of about 1¼ smooth whorls, apex bulbous. Teleoconch of about 2½ whorls; shell profile strong convex, suture shallow, whorl embracing much of previous whorl, a row of nodes between suture and collar-like adpressed zone, continues to a row of collabrally lengthened pustules at upper face of whorl. Aperture convex, lenticular in shape, columellar and inner lips thickened with strongly excavated, outer lip thin.

Dimensions.	H	W	PA	NW
Figured specimens				
(F78466)	5.0 mm	3.7 mm	90°	5
(F78465)	2.6	2.3	95	3½

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of the Namoi Formation.

**Material.** 7 specimens from south-east of 'Rangari' (Locality 18), 3 from Swains Gully (Locality 25), 2 from 'Marohn' (Locality 28) and 1 from Glenbawn (Locality 29).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Remarks.** The figured specimens resemble the holotype *Turbonitella biserialis* (Phillips) designated by Knight (1941) in being a turbiniform with strong collabral ribs on shoulder, but differs in lacking a row of ribs on the lower whorl face.

Order Uncertain

*Murchisonioidea* Koken, 1896

*Murchisoniidae* Koken, 1896

*Murchisonia* d'Archiac & de Verneuil, 1841

**Australian Carboniferous species.** *Murchisonia* sp. (in this study), from 'Marohn'.

*Murchisonia* sp.

Pl. 16 fig. 5

**Description.** Shell small, high-spined turreted form, thick, anomphalous or possibly with pseudoumbilicus. Protoconch unknown. Teleoconch of about 8 whorls; whorl profile angular at the periphery, but straight between pseudosuture and selenizone, and between selenizone and lower suture. Selenizone narrow, smooth on the periphery between 2 lirae. Aperture broken, pentagonal in shape with outer lip angled.

**Dimensions.** Figured specimen (F78482): H 5.8 mm, W 3.1 mm, PA 30°, NW 7½

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Additional material.** 4 specimens from the same locality.

**Geographic distribution.** 'Marohn'.

**Geological age.** Late Tournaisian.

**Remarks.** The species is characterised by a tall-spined and angular whorl with a selenizone on the periphery, resulting in a pentagonal shaped aperture. Specimens recovered are usually poorly preserved with the protoconch missing.

*Caenogastropoda* Cox, 1959

*Loxonematoidea* Koken, 1889

Family Uncertain

*Stegocoelia* Donald, 1889

**Australian Carboniferous species.** *Stegocoelia* (*Stegocoelia*) *nodosa* Yoo, 1988, from 'Marohn'; *Stegocoelia* (*Hypergonia*) *elongata* Yoo, 1988, from 'Marohn'; *Stegocoelia* (*Hypergonia*) *tenuis* Yoo, 1988, from 'Marohn'; *Stegocoelia* (*Hypergonia*) sp. A (in this study), from 'Kyndalyn'; *Stegocoelia* (*Hypergonia*) sp. B (in this study), from 'Kyndalyn'.

**Remarks.** *Stegocoelia* is transferred from the Murchisonioidea to Loxonematoidea on the basis of the morphological similarity of the protoconch to Loxonematoidea. *Stegocoelia* has a tall, smooth sinuated protoconch and dominant spiral cords on teleoconch without a distinct selenizone. In contrast, *Murchisonia* seems to have a simple protoconch and a distinct selenizone.

*Stegocoelia* (*Stegocoelia*) Donald, 1889

*Stegocoelia* (*Stegocoelia*) *nodosa* Yoo

Pl. 15 fig. 3

*Stegocoelia* (*Stegocoelia*) *nodosa* Yoo, 1988: 245, figs 67-71.

**Dimensions.** Figured specimen (F78467): H 3.7 mm, W 1.2 mm

**Additional material.** 75 specimens from 'Marohn' (Locality 28), 1 from Swains Gully (Locality 25) and 16 from south-east of 'Rangari' (Locality 18).

**Geographic distribution.** 'Rangari' to 'Marohn'.

**Geological age.** Middle to late Tournaisian.

*Stegocoelia (Hypergonia)* Donald, 1892

*Stegocoelia (Hypergonia) elongata* Yoo

*Stegocoelia (Hypergonia) elongata* Yoo, 1988: 245, figs 73-75.

**Additional material.** 28 from 'Marohn' (Locality 28), 3 from Swains Gully (Locality 25) and 1 from Glenbawn (Locality 29).

**Geographic distribution.** Swains Gully to Glenbawn.

**Geological age.** Middle to late Tournaisian.

*Stegocoelia (Hypergonia) tenuis* Yoo

Pl. 15 figs 4-8

*Stegocoelia (Hypergonia) tenuis* Yoo, 1988: 245, figs 76-79.

Dimension.	H	W	PA	NW
Figured specimens				
(F78468)	2.5 mm	0.5mm	9°	12
(F78470)	2.0	0.5	10	10½
(F78469)	2.4	—	—	12

**Additional material.** 62 specimens from 'Marohn' (Locality 28).

**Geographic distribution.** Type locality.

**Geological age.** Late Tournaisian.

**Remarks.** This species is easily confused in size and shape with other *Stegocoelia (Hypergonia)* spp., *Donaldina* spp. and species belonging to Pseudozygopleuridae, but is characterised by the deep sinus in the protoconch and three spiral striae in the lower face of whorl.

*Stegocoelia (Hypergonia)* sp. A

Pl. 15 figs 9-10

*Stegocoelia (Hypergonia)* sp. B

Pl. 15 figs 11-15

Dimensions.	H	W	PA	NW
Figured sp. A				
(F78472)	1.8 mm	0.8 mm	24°	8
(F78471)	2.6	0.9	18	8

Figured sp. B

(F78473)	2.8	—	—	10
(F78474)	3.9	—	—	12
(F78475)	2.8	—	—	9½

**Locality.** In base of oolitic limestone, behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW (Locality 24).

**Stratigraphic position.** Base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Material.** 24 specimens from 'Kyndalyn' (Locality 24).

**Geographic distribution.** Above locality only.

**Geological age.** Middle or late Viséan.

Palaeozygopleuridae Horny, 1955

*Palaeozygopleura* Horny, 1955

**Australian Carboniferous species.** *Palaeozygopleura obesa* n.sp., from 'Marohn'.

*Palaeozygopleura obesa* n.sp.

Pl. 16 figs 1-4

*Palaeozygopleura* sp. Yoo, 1988: 238, table 2.

**Description.** Shell small, high-spined cyrtocoid, anomphalous. Protoconch of about 1½ smooth whorls, tending to be globose. Teleoconch of about 7 whorls with whorl profile of the upper surface flattened and the lower surface slightly convex; suture shallow, collabral ribs evenly spaced across the whorl and slightly opisthocyrte with transition from protoconch to teleoconch not distinct. Aperture incomplete (broken specimen).

Dimensions.	H	W	PA	NW
Holotype (F78477)	10 mm	3.2 mm	25°	8
Paratypes (F78479)	5.2	2.5	28	8
(F78478)	5.6	2.2	24	8

**Types.** Holotype (F78477) and 2 figured paratypes (F78478-9). There are 14 additional specimens (F78476) from the type locality.

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Additional material.** 4 specimens from 'Rangari' area (Localities 15 and 18) and 26 from various horizons at Glenbawn (Localities 29-32).

**Geographic distribution.** 'Rangari' to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Derived from the Latin *obesus* meaning swollen.

**Remarks.** This is only species referred to

*Palaeozygopleura*, characterised by its high-spined cyrtoconoid shell with smooth globose protoconch. With the additional specimens recovered between 'Rangari' and Glenbawn, *Palaeozygopleura* sp. Yoo (1988) is here named *obesa*.

### **Pseudozygopleuridae Knight, 1930**

#### ***Pseudozygopleura* Knight, 1930**

**Australian Carboniferous species.** *Pseudozygopleura gracilis* n.sp., from 'Kyndalyn'.

#### ***Pseudozygopleura gracilis* n.sp.**

Pl. 16 figs 10-11

**Description.** Shell minute, slender, high spired, many whorled, anomphalous. Protoconch of about 3 whorls, the first whorl smooth, and the others with deeply sinuated transverse costae, transition from protoconch to teleoconch abrupt. Teleoconch of about 7 whorls; whorl profile rounded and somewhat pendant, suture moderately deep, surface smooth or ornamented by faint growth lines. Aperture circular in shape; inner lip thin, reflexed; parietal wall lacking, outer lip sharp with only a very slight sinus, nearly straight; base rounded.

**Dimensions.** Holotype (F78483): H 1.5 mm, W 0.5 mm, PA 20°, NW 9.

**Types.** Holotype (F78483) and 1 paratype (F78493).

**Type locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW (Locality 24).

**Stratigraphic position.** In base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle or late Viséan.

**Etymology.** Derived from the Latin *gracilis* meaning slender, slim.

**Remarks.** This is a very rare species. Two specimens recovered for this study are characterised by the presence of the typical pseudozygopleurid protoconch, tall smooth teleoconch whorls which are almost symmetrically arched, and a circular shape of aperture. There is no other form comparable to this species.

#### ***Leptozyga* Knight, 1930**

**Australian Carboniferous species.** *Leptozyga costata* n.sp., from 'Kyndalyn'.

#### ***Leptozyga costata* n.sp.**

Pl. 16 figs 8-9

**Description.** Shell minute, high spired, cyrtoconoid

with 7 whorls, anomphalous. Protoconch of 3 whorls, the first 1¼ whorls are smooth, and the remaining one and three quarter whorls have deeply sinuated strong collabral costae; the transition from protoconch to teleoconch abrupt, although transition within the protoconch gradual. Teleoconch of 4 whorls, whorl profile gently arched, suture moderately deep, first whorl of teleoconch ornamented by growth line only, remainder bearing collabral costae. Aperture subcircular in shape, columellar lip thin, nearly straight somewhat reflexed; parietal inductura lacking; outer lip thin, nearly straight, orthocline; base somewhat extended.

**Dimensions.** Holotype (F78481): H 1.6 mm, W 0.4 mm, PA 28°, NW 9.

**Types.** Holotype (F78481).

**Type locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW (Locality 24).

**Stratigraphic position.** In base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle or late Viséan.

**Etymology.** Derived from the Latin *costatus* meaning a rib; referring to collabral ribs on shell.

**Remarks.** This is an extremely rare species. Although a single specimen is available, the excellent preservation of the specimen warrants the naming of the specimen. *Leptozyga costata* n.sp. resembles *Palaeozygopleura obesa* n.sp. and *Hemizyga decussata* Yoo in being a cyrtoconoid with collabral cords, but differs in being minute and in having deep sinuous ornament on the protoconch.

#### ***Hemizyga* Girty, 1915**

**Australian Carboniferous species.** *Hemizyga decussata* Yoo, 1988, from 'Marohn'.

#### ***Hemizyga decussata* Yoo**

Pl. 16 figs 12-14

*Hemizyga (Hemizyga) decussata* Yoo, 1988: 246, figs 88-91.

#### **Dimensions.**

	H	W
Figured specimens (F78484)	3.5 mm	1.7 mm
(F78485)	2.3	1.4
(F78486)	3.2	1.7

**Additional material.** 10 specimens from 'Marohn' (Locality 28), and 10 specimens from various horizons at Glenbawn (Localities 29-31).

**Geographic distribution.** Glenbawn area.

**Geological age.** Late Tournaisian.

**Remarks.** An excellently preserved protoconch with reticulate ornamentation is illustrated by Yoo (1988: figs 89, 90).

*Cyclozyga* Knight, 1930

**Australian Carboniferous species.** *Cyclozyga sinusigera* Yoo, 1988, from 'Marohn'; *Cyclozyga* sp. (in this study), from 'Kyndalyn' (Pl. 19 figs 5-8).

*Cyclozyga sinusigera* Yoo

Pl. 16 figs 6-7

*Cyclozyga sinusigera* Yoo, 1988: 247, figs 92-94.

**Dimensions.** Figured specimen (F78480): H 1.3 mm, W 0.4 mm.

**Additional material.** 1 specimen from 'Marohn' (Locality 28).

**Stratigraphic position.** In upper part of the Dangarfield Formation.

**Remarks.** This is an extremely rare species. *Cyclozyga* sp. (Pl. 19 figs 5-8) from 'Kyndalyn' resembles *C. sinusigera* Yoo in shell shape and ornamentation, but differs in having closely spaced collabral lirae on teleoconch. Only two specimens of *Cyclozyga* sp. are obtained. The systematic position of *Cyclozyga* was discussed by Knight (1930a), and Hoare & Sturgeon (1978). The North American species of *Cyclozyga* have more strongly developed revolving costellae and are more attenuate in form.

**Subulitoidea** Lindstrom, 1884

**Subulitidae** Lindstrom, 1884

**Subulitinae** Lindstrom, 1884

***Ceraunocochlis*** Knight, 1931

**Australian Carboniferous species.** *Ceraunocochlis australis* n.sp., from 'Marohn' (= *Ceraunocochlis* sp., Yoo, 1988: 238, table 2); *Ceraunocochlis tenuis* n.sp., from 'Marohn'.

*Ceraunocochlis australis* n.sp.

Pl. 17 figs 6-10

**Description.** Shell very small, subulate, high spired, thin, axis of shell slightly curved, anomphalous. Protoconch of about 1½ smooth whorls, flattened top slightly tilted with strongly arched whorl profile; transition from protoconch to teleoconch sharp and gently sinuated. Teleoconch of about 7 smooth whorls, whorl profile flat to arched, suture shallow but distinct; length of whorl increases with growth. Aperture sharp triangular in shape; columellar lip merging with the parietal lip, thin, straight; distinct anterior siphonal notch; columellar fold obscured; outer lip straight,

slightly prosocline; base pointed and extended.

<b>Dimensions.</b>		H	W	NW
Holotype	(F78490)	3.4 mm	0.8 mm	8
Paratypes	(F78491a)	3.7	0.8	8
	(F78491b)	3.2	0.8	4½
	(F78491c)	3.0	0.7	5

**Types.** Holotype (F78490) and 3 figured paratypes (F78491). There are 46 unfigured additional specimens (F78492) from the type locality.

**Type locality.** 150 m west of 'Marohn' homestead, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** Bioclastic limestone, upper part of the Dangarfield Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Late Tournaisian.

**Etymology.** Derived from the Latin *australis* meaning southern.

**Remarks.** This species differs from *Ceraunocochlis tenuis* n.sp. in having more subulate shell, higher whorls and a sharp-angled aperture. The type species, *Ceraunocochlis fulminula* Knight, differs from *australis* in having the final whorl occupying more than half of the shell length.

*Ceraunocochlis tenuis* n.sp.

Pl. 17 figs 11-13

**Description.** Shell very small, high-spined with many whorls, thin, anomphalous. Protoconch of about 1½ smooth whorls, flattened top with strongly arched whorl profile; the transition from protoconch to teleoconch sharp and gently sinuated. Teleoconch of 7½ smooth whorls, whorl profile arched, suture moderately deep, deeper in neanic stage; length of whorl gradually increased with growth. Aperture D-shaped; inner lip almost straight, broad anterior notch, columellar fold obscured, parietal inductura thin; outer lip straight, strong prosocline; base pointed.

**Dimensions.** Holotype (F78494): H 2.3 mm, W 0.5 mm, NW 9.

**Types.** Holotype (F78494) and 1 paratype (broken).

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Late Tournaisian.

**Etymology.** Derived from the Latin *tenuis* meaning thin, slender; referring to its slender shell shape.

**Soleniscinae** Wenz, 1938

***Strobeus*** de Koninck, 1881

**Australian Carboniferous species.** *Strobeus ovalis* n.sp., from 'Marohn' (= *lanthinopsis* sp. Yoo, 1988: 238).

*Strobeus ovalis* n.sp.

Pl. 18 figs 8-12

**Description.** Shell very small, globular fusiform, moderately thick, anomphalous. Protoconch of small with simple, smooth whorls. Teleoconch of about 3½ whorls. First 2 whorls of the shell small, with other whorls markedly inflated, forming a shoulder on the upper part of the third whorl; whorl profile between sutures round in early whorls and rather straight in later whorls, suture shallow, not impressed. Aperture suboval; columellar lip moderately thickened, with a strong fold at the lower end of the columellar, fold obscured by columellar lip in some specimens; anterior siphonal canal broadly rounded.

Dimensions.	H	W	PA	NW
Holotype (F78501)	1.9 mm	1.4 mm	68°	4
Paratype (F78498)	1.7	1.4	74	4
Figured specimens				
(F78500a)	3.0	1.5	70	4
(F78500b)	1.9	1.4	70	4½
(F78500c)	2.6	1.9	—	4

**Types.** Holotype (F78501) and 1 figured paratype (F78498). There are 10 unfigured additional specimens (F78499) from the type locality.

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Additional material.** 3 figured specimens (F78500) from Glenbawn (Locality 30).

**Geographic distribution.** Glenbawn area.

**Geological age.** Late Tournaisian.

**Etymology.** Derived from the Latin *ovatus* meaning like an egg.

*Soleniscus* Meek & Worthen, 1861

**Australian Carboniferous species.** *Soleniscus callosus* Yoo, 1988, from 'Marohn'; *Soleniscus* sp. (in this study) from Swains Gully.

*Soleniscus callosus* Yoo

Pl. 18 figs 2-4

*Soleniscus callosus* Yoo, 1988: 247, figs 95-102.

Dimensions.	H	W	PA	NW
Figured specimens				
(F78502a)	7.2 mm	4.3 mm	52°	7
(F78502b)	7.3	4.4	50	8
(F78502c)	7.7	4.6	52	7½

**Geographic distribution.** 'Rangari' to Glenbawn.

**Additional material.** 15 specimens from 'Marohn' (Locality 28), 15 from Swains Gully (Locality 25), 12 from south-east of 'Rangari' (Locality 18), 51 from various horizons at Glenbawn (Localities 29-31).

**Geological age.** Middle to late Tournaisian.

**Remarks.** Ninety-three specimens recovered from 'Rangari' to Glenbawn demonstrate a considerable variation in shell shape and whorl profile.

*Soleniscus* sp.

Pl. 18 figs 1, 5-7

**Description.** Shell small, moderately high-spined fusiform, anomphalous. Protoconch small, simple. Teleoconch of about 4½ smooth whorls, shell profile gently rounded, suture shallow; last whorl much inflated; base rounded. Aperture suboval, pointed posteriorly, rounded anteriorly; outer lip moderately thick, arcuate; columellar lip arcuate with columellar fold; parietal inductura covered with a cluster of nodules.

Dimensions.	H	W	PA	NW
Figured specimens				
(F78504)	6.5 mm	4.4 mm	60°	6½
(F78505)	3.8	2.6	65	6

**Locality.** Approximately 250 m west of Babbins Lane in Swains Gully, 15 km south-east of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of Namoi Formation.

**Geological age.** Middle Tournaisian.

**Remarks.** This form is identical to *S. callosus* Yoo in size and shape; the only difference is that this form has a slightly larger pleural angle and the parietal inductura which is covered with a cluster of nodules. The nodules seem to disappear inside the shell probably by resorption. One specimen (Pl. 18 fig. 1), with a broken aperture, has no sign of nodules on the parietal area, but is considered to be the same form on the basis of the pleural angle and the much inflated final whorl.

## Meekospiridae Knight, 1956

*Girtyspira* Knight, 1936

**Australian Carboniferous species.** *Girtyspira inflata* n.sp., from Swains Gully.

**Remarks.** Kollmann & Yochelson (1976) transferred *Girtyspira* from the subulitoideans to the opisthobranchs, on the basis of a deviated protoconch and sutural ramp. Erwin (1988) also placed *Girtyspira* in the opisthobranchs. The studied form *Girtyspira inflata* n.sp. has a deviated protoconch, but not seen clearly as heterostrophic. It is, here, retained in the Subulitoidea.



*Girtyspira inflata* n.sp.

Pl. 19 figs 9-11

**Description.** Shell very small, thick, canaliculate fusiform, anomphalous. Protoconch of smooth, simple. Teleoconch of 4½ smooth whorls, whorl profile very gently arched; but with a narrow flattened shoulder, close to upper suture; angular, shallow suture formed between shoulder and whorl; base considerably extended. Aperture elongate, anteriorly extended with siphonal notch, columellar lip arcuate; adapical channel of aperture angled.

Dimensions.	H	W	NW
Holotype (F78515)	2.2 mm	1.3 mm	6
Paratype (F78516)	2.6	1.4	4½

**Types.** Holotype (F78515) and 1 figured paratype (F78516).

**Type locality.** 'Lorrina' homestead, 8 km south-west Somerton, NSW (Locality 23).

**Stratigraphic position.** In bioclastic limestone, upper part of the Namoi Formation.

**Additional material.** 2 more specimens from the type locality and 3 unfigured specimens from Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Geographic distribution.** Swains Gully area.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Derived from the Latin *inflatus* meaning swollen.

**Remarks.** This is only species so far referred to *Girtyspira* in Australia. *Girtyspira inflata* n.sp. has more canaliculate whorl shoulders and more inflated last whorl than the type species *Girtyspira canaliculata* (Hall).

Family Uncertain

*Globobulimorpha* n.gen.

**Type species.** *Globobulimorpha costata* n.sp.

**Definition.** Shell minute, thin, globular fusiform with round base. Protoconch deviated with final whorl embracing much of earlier whorl ornament of fine collabral threads; aperture large with strong columellar siphonal fold.

**Geological age.** Late Tournaisian.

**Remarks.** No existing genus can be compared with *Globobulimorpha*. The protoconch of the genus is deviated, but it is not clearly seen as heterostrophic.

**Australian Carboniferous species.** *Globobulimorpha costata* n.sp.

*Globobulimorpha costata* n.sp.

Pl. 23 figs 1-7

**Description.** Shell minute, low-spined globose, fusiform, anomphalous. Protoconch of 1-1¼ smooth whorls, deviated. Teleoconch of about 3 whorls of

thin shell, last whorl embracing much of previous whorls; whorl profile strongly arched; suture deep; ornament consisting of fine prosocline collabral lirae; base rounded. Aperture large, subcircular; columellar lip with a strong siphonal fold; siphonal channel below fold very wide; parietal inductura lacking or narrowly confined to the region close to the columellar, outer lip thin, straight.

Dimensions.	H	W	PA	NW
Holotype (F78495)	1.9 mm	1.5 mm	94°	4½
Paratypes (F78496a)	1.7	1.3	79	4
(F78496b)	2.0	1.6	—	—
(F78497)	1.5	1.1	85	4

**Types.** Holotype (F78495) and 4 figured paratypes (F78496-7).

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Additional material.** 26 specimens from the type locality (F78507).

**Geographic distribution.** Type locality only.

**Geologic age.** Late Tournaisian.

**Etymology.** Derived from the Latin *costatus* meaning costate, bearing ribs.

**Remarks.** This species resembles *Strobeus ovalis* n.sp., and species of *Soleniscus* in possessing a columellar fold, but differs in having a thinner shell layer, strongly arched whorls ornamented with fine collabral lirae.

Order, Superfamily and Family Uncertain

*Microcochlis* n.gen.

**Type species.** *Microcochlis parva* n.sp.

**Definition.** Minute, turbiniform with shallow sutures, somewhat flat whorl profile, and narrow umbilicus; ornament of rather widely spaced prosocline collabral cords with weak spiral cords.

**Geological age.** Late Tournaisian.

**Remarks.** *Microcochlis* n.gen. differs from *Eucochlis* Knight and *Kyndalynia* n.gen. in having a flat whorl profile and coarser collabral cords modified with weaker spiral cords. It has a narrow umbilicus as seen in some species of *Eucochlis*, but differs from *Kyndalynia* in that the latter has a round whorl profile and a wide umbilicus.

**Australian Carboniferous species.** *Microcochlis parva* n.sp.

*Microcochlis parva* n.sp.

Pl. 12 figs 1-5

**Description.** Shell minute, relatively high-spined turbiniform, narrowly phaneromphalous. Protoconch

simple consisting of one and one eighth smooth whorls, with sharp irregular boundary between protoconch and teleoconch. Teleoconch whorl profile arched in early stage and rather straight in late stage, suture shallow, base subangular; first 1¼ whorls with gently prosocline, fine collabral lirae followed by strong collabral cords extended to umbilicus, with cords straight, prosocline, and evenly spaced but becoming gradually wider with growth, ornamented by 4 spiral rows of pustules on final whorl between periphery and the upper suture. Aperture subrectangular, inner lip thin, nearly straight, outer lip thin, straight prosocline.

Dimensions.	H	W	PA	NW
Holotype (F78437)	2.1 mm	1.5 mm	56°	4½
Paratypes (F78438a)	1.4	1.2	54	3½
(F78438b)	1.3	1.0	56	4

**Types.** Holotype (F78437), 2 figured paratypes (F78438) and 2 unfigured paratypes (F78439).

**Type locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerston, NSW (Locality 24).

**Stratigraphic position.** In base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle or late Viséan.

**Etymology.** Derived from the Latin *parvus* meaning minute.

**Remarks.** *Microcochlis parva* n.sp. differs from *Eucochlis umbiliparva* n.sp. in having a smaller shell, short blunt protoconch and prominent spiral rows of pustules. Figures 1 and 2 in Plate 12 are juveniles, showing an arched whorl profile and only faint expression of spiral cords. The spiral angulation begins to appear at 2½ whorls.

## Elasmonematidae Knight, 1956

### *Eucochlis* Knight, 1933

**Australian Carboniferous species.** *Eucochlis australis* Yoo, 1988, from 'Marohn'; *Eucochlis depressa* n.sp., from Swains Gully; *Eucochlis umbiliparva* n.sp., from Swains Gully; *Eucochlis* sp., from Glenbawn.

**Remarks.** All four Australian forms are similar in size and ornament. *Eucochlis australis* Yoo, *Eucochlis depressa* n.sp. and *Eucochlis* sp. are moderately phaneromphalous and have fine spiral threads, while *Eucochlis umbiliparva* n.sp. is minutely phaneromphalous and has no spiral threads. *Eucochlis depressa* has an exceptionally depressed final whorl, and *Eucochlis* sp. has a low spire and much inflated final whorl.

### *Eucochlis australis* Yoo

Pl. 13 figs 2-3

*Eucochlis australis* Yoo, 1988: 243, figs 61-64.

Dimensions.	H	W
Figured specimens (F78446)	2.2 mm	1.5 mm
(F78447)	1.4	0.8

**Additional material.** 75 specimens from 'Marohn' (Locality 28), 7 and 15 from Glenbawn (Localities 29 and 30 respectively).

### *Eucochlis depressa* n.sp.

Pl. 13 figs 7-11

**Description.** Shell minute, turbiniform, compressed, moderately phaneromphalous. Protoconch of 1¼ whorls with fine growth lines. Teleoconch of 2½ strongly convex whorls with narrowly and evenly spaced sharp collabral cords and weak spiral lirae, collabral cords (about 52 in the last whorl) strong, oblique, prosocline, 40° from axis, suture deep. Aperture almost rectangular, lips thin, outer lip strongly retracted.

Dimensions.	H	W	PA	NW
Holotype (F78451)	1.6 mm	1.5 mm	85°	4½
Paratypes (F78453)	1.6	1.6	95	4½
(F78452)	1.6	1.4	90	4

**Types.** Holotype (F78451) and 2 figured paratypes (F78452-3). There are 2 unfigured additional specimens (F78435) from the type locality.

**Type locality.** Approximately 250 m west of Babbins Lane, in Swains Gully, 15 km south-west of Somerton, NSW (Locality 25).

**Stratigraphic position.** In bioclastic limestone, 130 m above the base of the Namoi Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle Tournaisian.

**Etymology.** Derived from the Latin *depressus* meaning low-lying, sunk down; referring to depressed shell.

**Remarks.** This species is characterised by an exceptionally depressed last whorl with strongly retracted outer lip.

### *Eucochlis umbiliparva* n.sp.

Pl. 13, figs 4-6

**Description.** Shell-minute, turbiniform, minutely phaneromphalous. Protoconch of 1¼ smooth whorls with fine growth lines. Teleoconch of 3½ strong convex whorls between deeply impressed sutures, with approximately 42 gently prosocline collabral cords evenly spaced in the last whorl, spiral threads restricted on the base. Aperture simple, almost rectangular, lips slightly thickened, parietal inductura wanting, outer lip nearly straight prosocline or very slightly concave forward.

Dimensions.	H	W	PA	NW
Holotype (F78448)	1.7 mm	1.7 mm	75°	4½
Paratypes (F78449)	1.8	1.5	68	4¼
(F78450)	1.8	—	72	4

**Types.** Holotype (F78448) and 2 figured paratypes (F78449-50). There are 5 unfigured additional specimens (F78436).

**Type locality.** 1.8 km east from the southern end of Glenbawn Dam wall, 13 km north-east of Aberdeen, NSW (Locality 31).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Additional material.** 1 specimen from 'Marohn' (Locality 28) and 1 from Glenbawn (Locality 29).

**Geographic distribution.** Glenbawn area.

**Geological age.** Late Tournaisian.

**Etymology.** Derived from the Latin *umbilicus* meaning centre, *parvus* meaning little, small; referring to a small umbilicus.

### *Eucochlis* sp.

Pl. 13 fig. 1

**Dimensions.** Figured specimen (F78445): H 1.6 mm, W 1.8 mm, PA 100°, NW 4.

**Stratigraphic position.** Upper part of the Dangarfield Formation.

**Locality.** 1.8 km east of the southern end of Glenbawn Dam wall, NSW (Locality 31).

### *Kyndalynia* n.gen.

**Type species.** *Kyndalynia inflata* n.sp.

**Definition.** A very small, turbiniform gastropod with rounded whorls; protoconch smooth, bulbous; whorls expand rapidly, widely phaneromphalous; ornament a prosocline to orthocline collabral cords with faint spiral threads.

**Geological age.** Middle or late Viséan.

**Etymology.** Referring to the geographical name of the homestead where this genus occurs.

**Remarks.** *Kyndalynia* n.gen. is different in shell character from any other described Palaeozoic gastropods. The closest form is *Eucochlis*, but *Kyndalynia* has more inflated whorls and wider umbilicus.

**Australian Carboniferous species.** *Kyndalynia inflata* n.sp.

### *Kyndalynia inflata* n.sp.

Pl. 12 figs 6-11

**Description.** Shell minute, cyrtocoidal, widely phaneromphalous. Protoconch of 1½ smooth whorls with slightly deviated bulbous apex, boundary with teleoconch sharp. Teleoconch with first whorl with fine growth line, followed by 2½ rounded whorls with evenly spaced collabral riblets with about 32 in the last whorl, spire outline very convex, suture impressed.

Aperture circular, lips slightly thickened, with outer lip prosocline.

Dimensions.	H	W	PA	NW
Holotype (F78440)	1.3 mm	— mm	70°	4½
Paratypes (F78441a)	1.1	1.0	70	4¼
(F78441b)	1.1	1.0	68	4
(F78443)	1.2	1.0	67	4
(F78442)	1.0	1.0	76	4

**Types.** Holotype (F78440) and 4 figured paratypes (F78441-3). There are 14 unfigured additional specimens (F78444) from the type locality.

**Type locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW (Locality 24).

**Stratigraphic position.** In base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Middle or late Viséan.

**Etymology.** Derived from the Latin *inflatus* meaning swollen; referring to inflated whorls.

**Remarks.** This species is characterised by having very inflated whorl profile. This is relatively rare in the type locality. No other Australian form has so far been referred to this genus.

### Heterogastropoda

Superfamily and Family Uncertain

### *Kimina* n.gen.

**Type species.** *Kimina globosa* n.sp.

**Definition.** Shell minute, thin, globose to elongate, narrowly phaneromphalous. Surface smooth except for very weak growth lines. Protoconch deviated, aperture simple, circular.

**Geological age.** Late Tournaisian.

**Etymology.** This genus is named after my wife Kim to record her contributions throughout this study.

**Remarks.** This genus is similar to recent genus *Rissoella* in shell and protoconch characters, and is different from any known Palaeozoic gastropods. *Rissoella* which is characterised by a simple, sometime deviated protoconch was included tentatively in the Heterogastropoda by Ponder & Yoo (1977), a group which shows mixed opisthobranch and prosobranch characters. Climo (1975) has outlined the characteristics of some families of the Heterogastropoda and suggested that the Heterogastropoda shows more affinities with opisthobranchs than mesogastropods. However, Ponder & Waren (1988) assigned the Heteromorpha to the same rank as the Opisthobranchia under subclass Heterobranchia. *Kimina* is tentatively included in the Heterogastropoda.

**Australian Carboniferous species.** *Kimina australis* n.sp., from 'Kyndalyn'; *Kimina globosa* n.sp., from 'Marohn'; *Kimina minor* n.sp., from 'Marohn'; *Kimina* sp. from 'Marohn'.

*Kimina australis* n.sp.

Pl. 19 figs 1-4

**Description.** Shell minute, high spired, smooth, thin, narrowly phaneromphalous. Protoconch of  $1\frac{1}{4}$  smooth whorls, the apex slightly deviated hiding the first half whorl in side view. Teleoconch of up to 4 convex whorls, smooth except for very fine prosocline growth lines. Aperture simple, almost circular, with thin lips.

Dimensions.	H	W	PA	NW
Holotype (F78513)	1.3 mm	0.8 mm	46°	4½
Paratypes (F78511)	1.4	0.8	43	4½
(F78512)	1.3	0.9	50	4½

**Types.** Holotype (F78513) and 2 figured paratypes (F78511-2). There are 112 unfigured additional specimens (F78514).

**Type locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW (Locality 24).

**Stratigraphic position.** In base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geographic distribution.** Type locality only.

**Geological range.** Middle or late Viséan.

**Etymology.** Derived from the Latin *australis* meaning southern.

**Remarks.** Differs from *K. globosa* n.sp. in having prosocline growth lines.

*Kimina globosa* n.sp.

Pl. 20 figs 1-7

**Description.** Shell minute, thin, globose, rather short spired, narrowly phaneromphalous. Protoconch of  $1\frac{1}{4}$  smooth whorls, apex deviated, between protoconch and teleoconch sharp straight line; teleoconch of 3-4 very convex whorls, with surface smooth except for very distinct opisthocline growth lines, suture deep. Aperture simple, complete circular, lips thin.

Dimensions.	H	W	PA	NW
Holotype (F78508)	2.2 mm	1.4 mm	48°	5¼
Paratypes (F78509a)	1.4	1.0	60	4
(F78509b)	1.2	0.8	56	4½
(F78509c)	1.0	0.9	50	4¼
(F78509d)	1.1	0.8	60	4

**Types.** Holotype (F78508) and 4 figured paratypes (F78509).

**Type locality.** 150 m west of 'Marohn' homestead, 4 km south-west of Gundy, NSW.

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Late Tournaisian.

**Etymology.** Derived from the Latin *globosus* meaning globose.

**Remarks.** *Kimina globosa* n.sp. and *Kimina australis* n.sp. are similar in having a smooth shell with a deviated protoconch and moderate umbilicus, but different each other in that the former has opisthocline growth lines, while the latter has prosocline growth lines.

*Kimina minor* n.sp.

Pl. 17 figs 1-5

**Description.** Shell minute, moderately high spired, narrowly phaneromphalous. Protoconch of  $1\frac{1}{2}$  whorls, simple, smooth apex rather flat; margin of protoconch with teleoconch sharp. Teleoconch of about 4 whorls, whorl profile convex; sculpture of weak, axial growth lines. Aperture almost circular; anterior and posterior corners slightly angled; lips thin, parietal inductura lacking.

Dimensions.	H	W	PA	NW
Holotype (F78487)	5.3 mm	2.1 mm	30°	7
Paratypes (F78488)	2.1	1.2	40	4½
(F78489a)	2.0	1.3	40	5
(F78489b)	2.2	1.3	40	5½

**Types.** Holotype (F78487) and 2 paratypes (F78488-9).

**Type locality.** 150 m west of 'Marohn' homestead, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Additional material.** 8 unfigured specimens from Swains Gully (Locality 25), 2 from 'Lorrina' (Locality 23) and 2 from Glenbawn (Locality 28).

**Geographic distribution.** Swains Gully to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Remarks.** This species resembles the other *Kimina* species in shell shape, but differs in having a simple protoconch.

*Kimina* sp.

Pl. 22 figs 6-9

Dimensions.	H	W	NW
Figured specimens			
(F78526a)	1.9 mm	0.9 mm	6
(F78526b)	1.5	0.8	5¼

**Locality.** 150 west of 'Marohn' homestead, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Geographic distribution.** Above locality only.

**Geological age.** Late Tournaisian.

*Palaeoalvania* n.gen.

**Type species.** *Palaeoalvania talenti* n.sp.

**Definition.** Shell minute, rather high-spined, narrowly phaneromphalous. Surface ornament of spiral cords and opisthocline growth lines. Protoconch deviated; aperture simple, circular.

**Geological age.** Late Tournaisian.

**Remarks.** *Palaeoalvania* is very similar to *Kimina* in shell and protoconch characters, but differs in having spiral cords.

**Australian Carboniferous species.** *Palaeoalvania talenti* n.sp.

*Palaeoalvania talenti* n.sp.

Pl. 20 figs 8-13

**Description.** Shell minute, thin, rather high-spined, narrowly phaneromphalous. Protoconch of 1½ smooth whorls, apex deviated; sharp straight line between protoconch and teleoconch. Teleoconch of 4 very convex whorls, first ½ whorls smooth, remainder ornamented with spiral cords and distinct opisthocline growth lines; suture deep. Aperture simple, complete, circular and with thin lips.

Dimensions.	H	W	PA	NW
Holotype (F78454)	1.6 mm	1.1 mm	40°	4
Paratypes (F78455a)	1.9	1.0	32	4
(F78455b)	1.6	0.9	35	4

**Types.** Holotype (F78454) and 2 figured paratypes (F78455).

**Type locality.** 150 m west of 'Marohn' homestead, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Late Tournaisian.

**Etymology.** This species was named after Professor J.A. Talent, Macquarie University as an acknowledgment for his supervision of this work.

**Remarks.** This species differs from *Kimina globosa* n.sp. in possessing spiral cords, and from *Pseudoaclisina turgida* (Yoo) in having more convex whorls. *Palaeoalvania talenti* n.sp. resembles some Recent rissoids, particularly *Alvania*, in shell shape and ornament, but differs in having a deviated protoconch.

*Pseudoaclisina* n.gen.

**Type species.** *Aclisina turgida* Yoo, 1988: 244, figs 80-81.

**Definition.** Shell minute, with tall-spined convex whorls; protoconch smooth, deviated; teleoconch covered by numerous spiral threads; anomphalous.

**Geological age.** Middle to late Tournaisian.

**Etymology.** Derived from Genus *Aclisina* a genus of similar shape.

**Remarks.** The species *turgida* was originally placed in *Aclisina* (Yoo, 1988). A further examination of *A. turgida* indicates that it has a deviated protoconch. No selenizone or notch exists. The species *A. turgida* is here transferred from *Aclisina* to *Pseudoaclisina* n.gen.

**Australian Carboniferous species.** *Pseudoaclisina microspirulata* n.sp., from 'Marohn'; *Pseudoaclisina turgida* (Yoo), 1988 from 'Marohn'.

*Pseudoaclisina microspirulata* n.sp.

Pl. 21 figs 7-10

**Description.** Shell minute, high-spined, pupiform, anomphalous. Protoconch of 1½ smooth whorls, deviated and submerged, transition from protoconch to teleoconch abrupt. Teleoconch of about 7 whorls with about 22 fine spiral costae in the final whorl; opisthocline growth lines cover the teleoconch; whorl profile more or less symmetrically rounded; suture deep, well impressed; base rounded. Aperture oval, columellar lip arcuate; outer lip, thin, opisthocline.

Dimensions.	H	W	NW
Holotype (F78519)	2.7 mm	0.7 mm	8
Paratype (F78520)	1.8	0.6	6

**Types.** Holotype (F78519) and 1 figured paratype (F78520).

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Geographic distribution.** Type locality only.

**Geological age.** Late Tournaisian.

**Etymology.** Referring to the microspiral ornamentation of shell.

**Remarks.** This form is characterised by densely spaced fine spiral lirae and a deviated protoconch.

*Pseudoaclisina turgida* (Yoo)

Pl. 21 figs 11-13

*Aclisina turgida* Yoo, 1988: 244, figs 80-81.

Dimensions.	H	W	NW
Figured specimens			
(F78461a)	1.6 mm	0.8 mm	4½
(F78461b)	2.3	1.0	5½

**Additional material.** 7 specimens from Swains Gully (Locality 25), 19 from 'Marohn' (Locality 28), and 4 from Glenbawn (Locality 30).

**Geographic distribution.** Swains Gully to Glenbawn.

**Geological age.** Middle to late Tournaisian.

**Remarks.** This species differs from *Pseudoaclisina microspirulata* n.sp. in possessing coarser spiral threads.

**Opisthobranchia** Milne Edwards, 1848

Superfamily Uncertain

**Streptacididae** Knight, 1931***Donaldina*** Knight, 1933

**Australian Carboniferous species.** *Donaldina filosa* Yoo, 1988, from 'Marohn'; *Donaldina minutissima* n.sp., from 'Marohn'; *Donaldina* sp. (in this study), from 'Kyndalyn'.

***Donaldina filosa*** Yoo

Pl. 22 figs 12-14

*Donaldina filosa* Yoo, 1988: 248, figs 104-109.

**Dimensions.** Figured specimens (F78521a): H 2.2 mm, W 0.5 mm; (F78521b): H 1.4, W 0.5.

**Additional material.** 42 specimens from 'Marohn' (Locality 28) and 1 from Glenbawn (Locality 29).

***Donaldina minutissima*** n.sp.

Pl. 21 figs 1-6

*Donaldina* sp. Yoo, 1988: 238 (table 2), figs 110-111.

**Description.** Shell minute, slender, high-spined turriculate anomphalous. Protoconch of 1½ smooth whorls with deviated spire, the transition from protoconch to teleoconch indistinct orthocline. Teleoconch of about 8 convex whorls with early whorls smooth and later whorls ornamented with 6 evenly spaced spiral cords; whorl profile more or less symmetrically rounded; suture deep, well impressed. Aperture oval, columellar lip slightly arcuate; base rounded.

Dimensions.	H	W	NW
Holotype (F78517)	1.7 mm	0.6 mm	7½
Paratypes (F78510a)	1.7	0.4	7¼
(F78518)	2.6	0.6	10¼
(F78510b)	1.1	0.4	5¼

**Types.** Holotype (F78517) and 3 figured paratypes (F78510, 78518).

**Type locality.** 150 m west of 'Marohn' homestead, on the Scone-Gundy roadside, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Late Tournaisian.

**Etymology.** Derived from the Latin *minutissima* meaning extremely small.

**Remarks.** Six specimens recovered for this study are sufficiently well preserved to justify basing a new species. This new species resembles *Donaldina filosa* Yoo and *Pseudoaclisina microspirulata* n.sp. in having

a minute, slender and tall shell with fine spiral ornament, but it differs in having a more highly deviated protoconch.

***Donaldina*** sp.

Pl. 22 figs 10-11

**Dimensions.** Figured specimen (F78527): H 1.7 mm, W 0.5 mm, NW 9.

**Locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW (Locality 24).

**Stratigraphic position.** In base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geographic distribution.** Above locality only.

**Geological age.** Middle or late Viséan.

***Streptacis*** Meek, 1872

**Remarks.** This genus is introduced for the first time to the Australian fauna to accommodate *Loxonema elegantissima* Yoo, 1988, *Streptacis gundyensis* n.sp. and *Streptacis* sp. *Loxonema elegantissima* is here transferred to the genus *Streptacis* because of its minute shell with strong sinuous collabral lirae.

**Australian Carboniferous species.** *Streptacis elegantissima* (Yoo), from 'Marohn'; *Streptacis gundyensis* n.sp., from 'Marohn'; *Streptacis* sp. (in this study), from 'Kyndalyn'.

***Streptacis elegantissima*** (Yoo)

Pl. 22 figs 1-3

*Loxonema elegantissima* Yoo, 1988: 246, figs 84-87.

**Dimensions.** Figured specimens (F78524) H 1.9 mm, W 0.5 mm, NW 8¼; (F78523) H 1.6, W 0.5 mm, NW 7½.

**Additional material.** 50 specimens from 'Marohn' (Locality 28), one each from two horizons at Glenbawn (Localities 29 and 31).

**Remarks:** This species occurs commonly at the type locality. Fifty two specimens recovered for this study are extremely well preserved and readily referred to this species.

***Streptacis gundyensis*** n.sp.

Pl. 23 figs 8-13

**Description.** Shell minute, high-spined, anomphalous. Protoconch of 1¼ whorls, deviated. Teleoconch of 5 to 6 smooth, moderately convex whorls, with faint growth lines. Aperture circular to oval, lips thin, no



columellar fold.

Dimensions.	H	W	NW
Holotype (F78522)	2.5 mm	0.9 mm	7
Paratypes (F78528a)	2.1	0.8	6
(F78528b)	2.7	1.0	8
(F78531)	1.4	0.7	5

**Types.** Holotype (F78522) and 3 figured paratypes (F78528, 78531).

**Type locality.** 150 m west of 'Marohn' homestead, 4 km south-west of Gundy, NSW (Locality 28).

**Stratigraphic position.** In bioclastic limestone, upper part of the Dangarfield Formation.

**Geographic distribution.** Type locality only.

**Geological age.** Late Tournaisian.

**Etymology.** Referring to the township of Gundy, New South Wales.

**Remarks.** This species is similar to *Kimina* sp., in having smooth convex whorls with deviated protoconch, but *Kimina* sp. has a moderate umbilicus and more convex whorls with opisthocline growth lines.

### *Streptacis* sp.

Pl. 22 figs 4-5

**Description.** Shell minute, very slender, high-spired, anomphalous. Protoconch of heterostrophic but initial portion missing. Teleoconch of about 9 whorls with only opisthocline growth lines; whorl profile symmetrically rounded, suture deep. Aperture oval, inner lip arcuate; outer lip thin, opisthocline.

**Dimensions.** Figured specimen (F78525) H 2.0 mm, W 0.5 mm, NW 10.

**Locality.** Behind 'Kyndalyn' homestead, 10 km south-west of Somerton, NSW (Locality 24).

**Stratigraphic position.** In base of oolitic limestone in the Kyndalyn Mudstone Member of the Merlewood Formation.

**Geological age.** Middle or late Viséan.

**Remarks.** This specimen resembles *Streptacis elegantissima* (Yoo) in shell shape and ornament, but differs in having finer collabral threads and a helical heterostrophic protoconch.

### Concluding Remarks

During the present study, the largest assemblage to date of Australian Early Carboniferous gastropods (early Tournaisian to late Viséan) was recovered from the limestones interbedded in the Tulcumba Sandstone and the Namoi Formation in the western limb of the Belvue-Werrie Syncline, in the Merlewood Formation about 10 km southwest of Somerton, and in the Dangarfield Formation in the Glenbawn area. The faunal assemblage consists almost entirely of minute shells preserved by chlorite replacement, making possible the isolation from the limestone matrix of complete shells with preservation

of extremely delicate shell ornamentation. The gastropod shells in the Luton Formation, the Namoi Formation and the Caroda Formation in the northernmost Tamworth Belt do not appear to be replaced by chlorite. Only a small number of clayey internal molds was recovered after acidisation.

During this study, a total of 79 forms of gastropods referable to 47 genera and subgenera was discriminated, of which 40 forms are described as new species. The Australian gastropod faunas can be viewed as a mixture of both European and North American affinities. This agrees in a general way with the conclusions of previous workers that the Early Carboniferous marine invertebrate faunas of the Tasman Belt in eastern Australia were diverse and cosmopolitan. However, three genera (*Kimina*, *Palaeoalvania* and *Pseudoaclisina*) placed to the Heterogastropoda and two genera (*Microcochlis* and *Kyndalynia*) which I am unable to place to an order have not been observed outside Australia. Two other new genera, *Campbellospira* and *Globobulimorpha*, placed to Pleurotomarioidea and Subulitoidea respectively, are also unique in shell characters, and need further investigations. The Heterogastropoda and related forms had already diversified during the early Carboniferous. The origin of these groups are yet to be investigated.

**ACKNOWLEDGMENTS.** This is part of my PhD thesis prepared under the supervision of Professor John Talent of Macquarie University. I wish to express my sincere thanks to him and to Dr Ruth Mawson of the same University for continuous encouragement and helpful criticism during all the stages of this investigation. Dr W. F. Ponder of the Australian Museum, Sydney, and Dr J. M. Dickins of Bureau of Mineral Resources, Canberra, gave advice on molluscan taxonomy; Dr T.B.H. Jenkins of the University of Sydney provided data on conodont biostratigraphy; Mr R. Jones gave access to collections in the Australian Museum; Mr M. Leu of Macquarie University made available some acid-insoluble residues from Swains Gully and Kyndalyn; the staff of the Armidale Office of the Geological Survey of New South Wales supplied an unpublished geological compilation; the photomicrographs were prepared by the author in the Electron Microscope Unit, Macquarie University. I am very much indebted to Mr O. Mueller and Mrs L. Villareal, both of the Department of Mineral Resources for elegant photographic work and typing, respectively. Finally I wish to acknowledge Dr K. Bandel of the University of Hamburg, Dr D.H. Erwin of the National Museum of Natural History, Smithsonian Institution, Dr D.R. Lindberg of the University of California, Berkeley, and Professor A.J. Boucot of the Oregon State University for their valuable advice towards the improvement of this paper.

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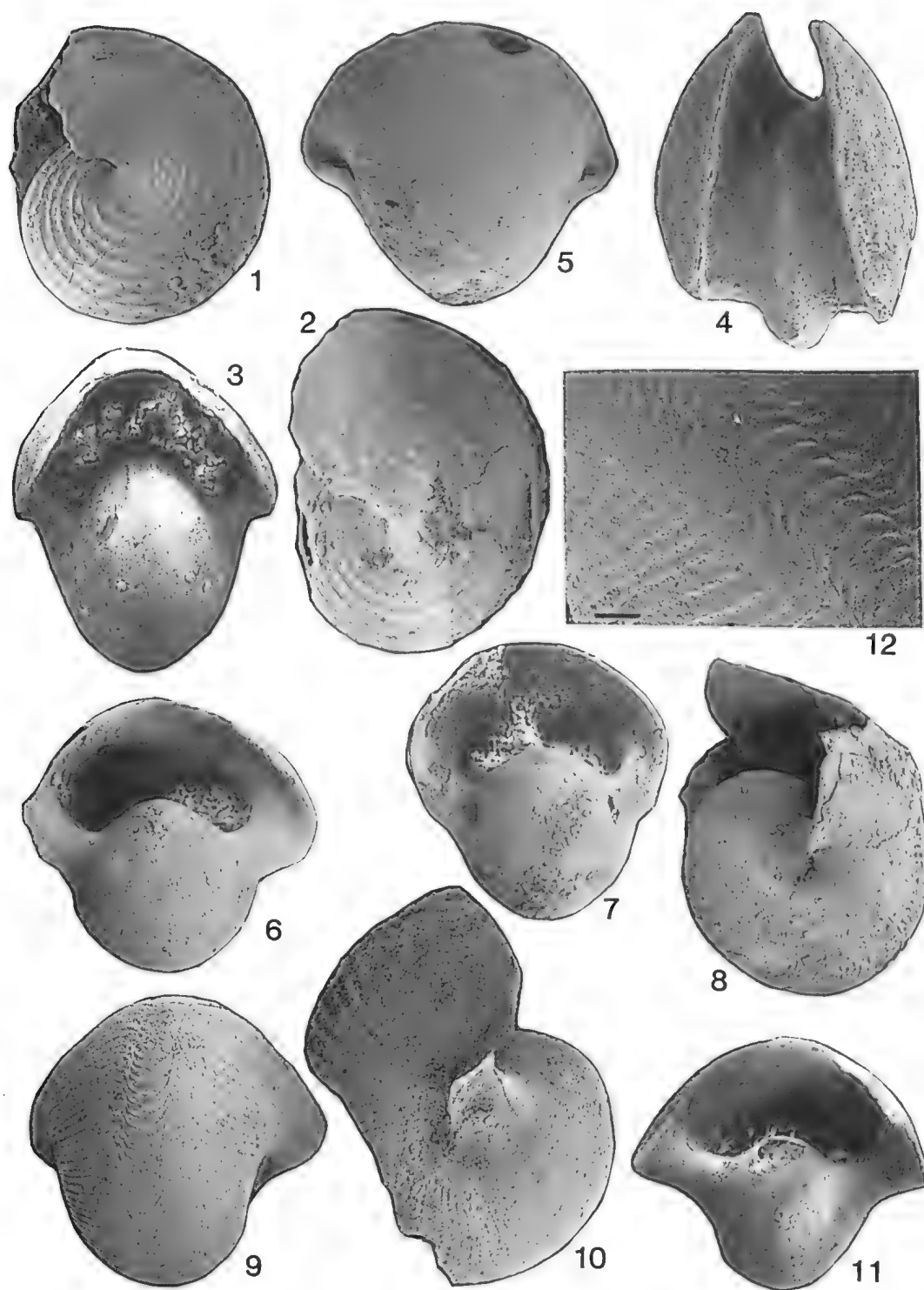
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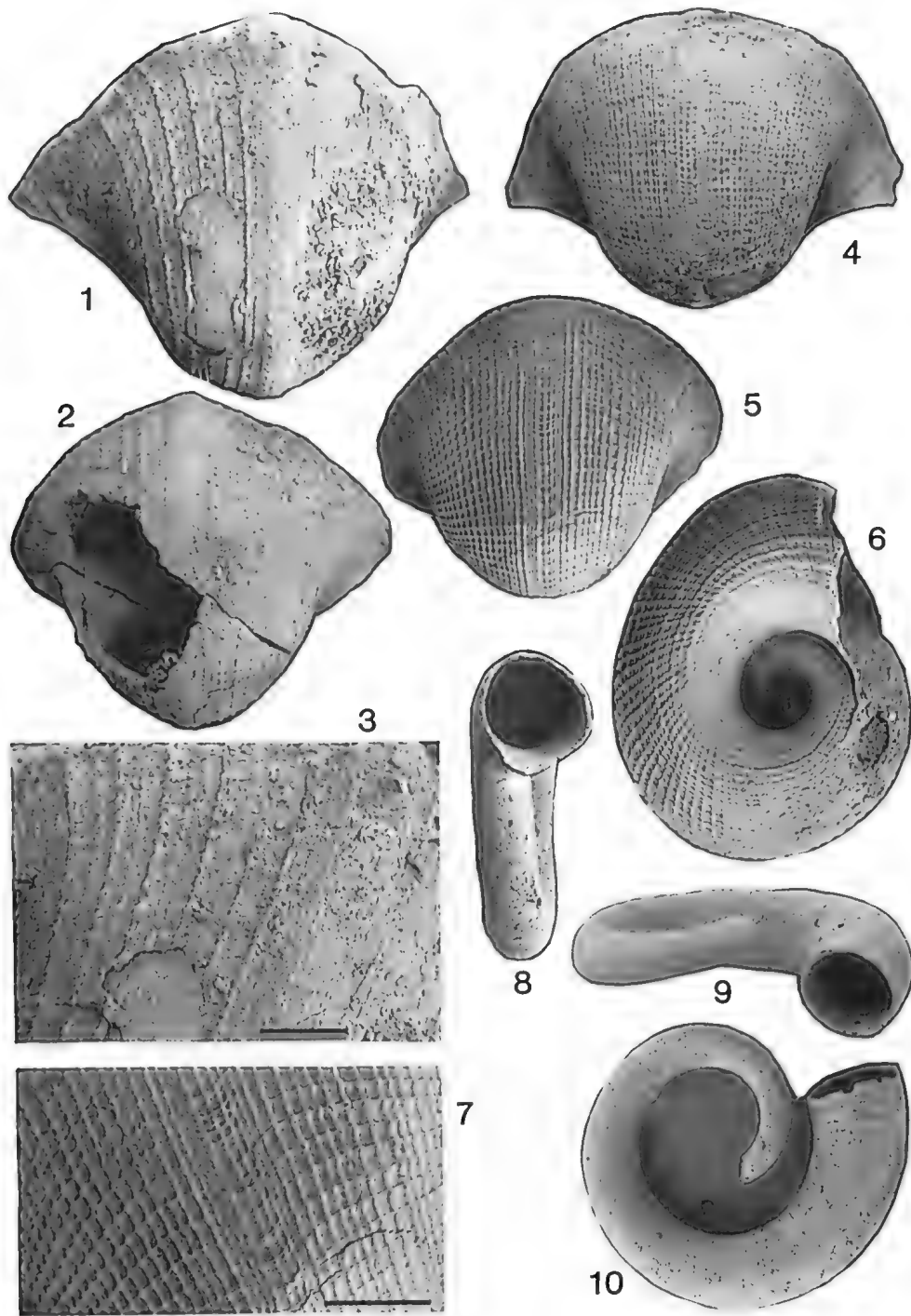
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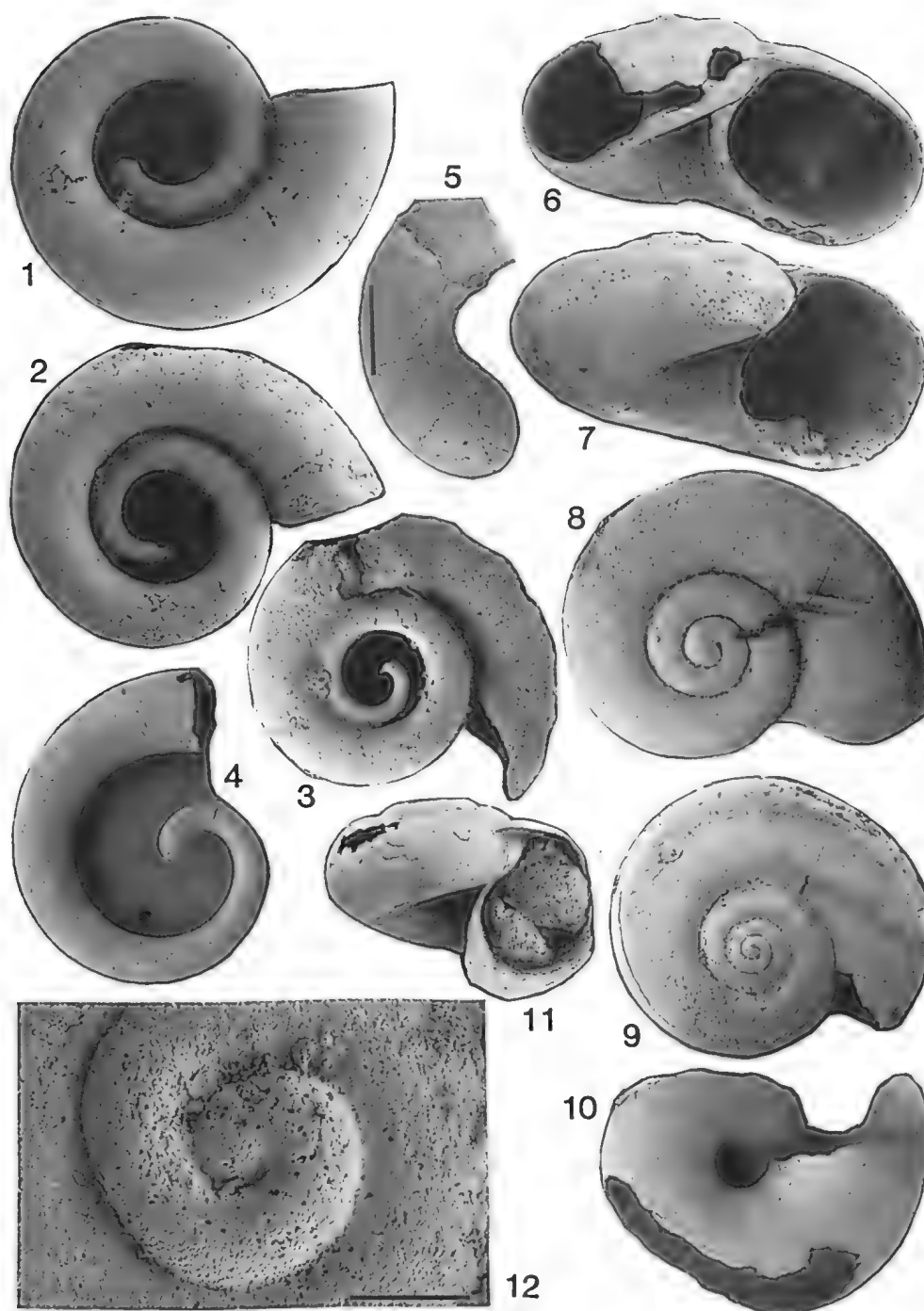
## APPENDIX



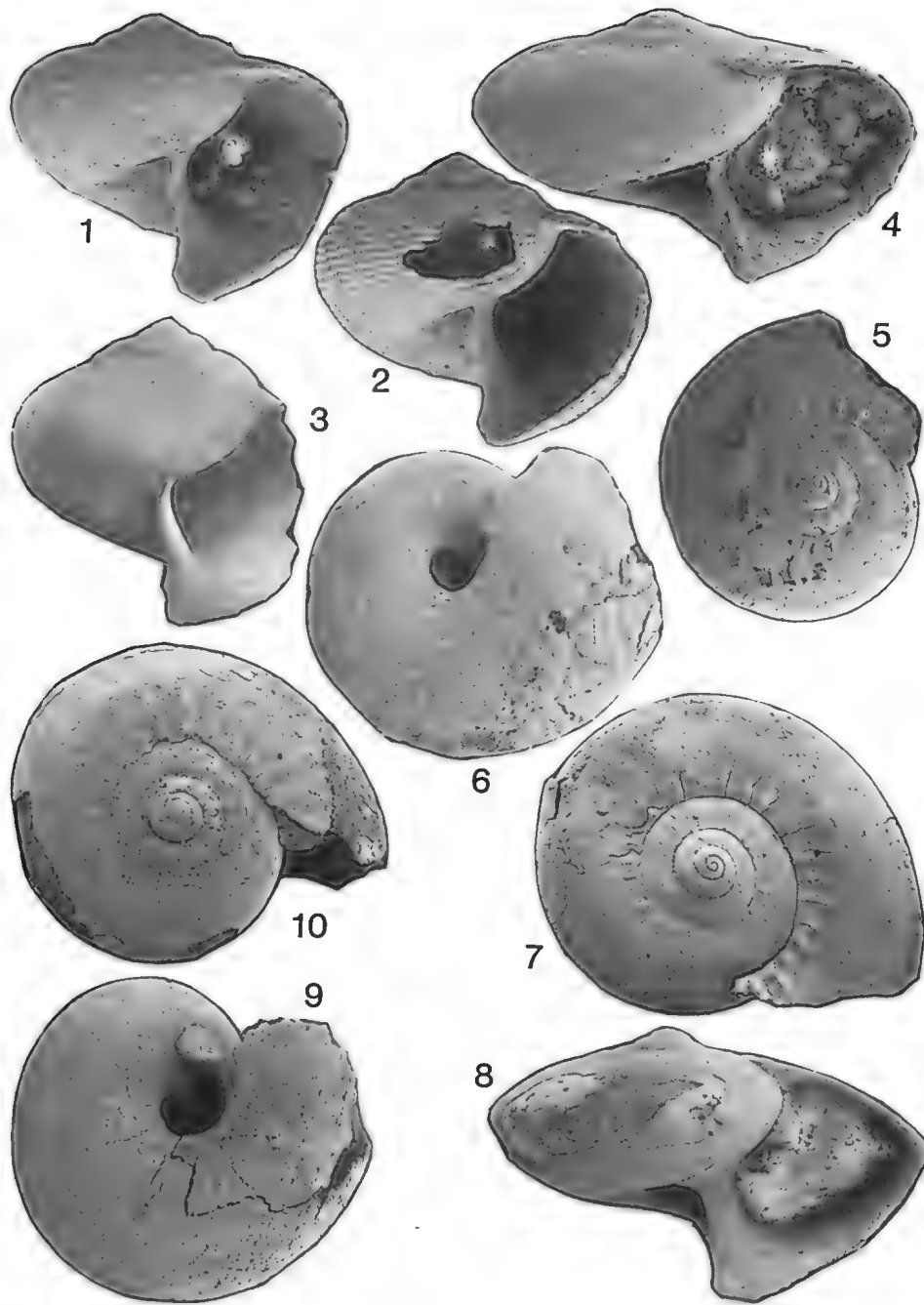
**Plate 1.** Figs 1-3. *Euphemites pustula* n.sp. 1. Paratypes, left lateral view, maximum diameter 3.4 mm (F78342). 2. Holotype, left lateral view, maximum diameter 4.6 mm (F78341). 3. Paratype, apertural view, maximum diameter 4.2 mm (F78342). Locality 25. Fig. 4. *Cybularia carinata* n.sp. Holotype, apertural view, maximum diameter 2.3 mm (F78343). Locality 25. Figs 5-8. *Bellerophon* (*Bellerophon*) *swainsensis* n.sp. 5. Paratype, anterior dorsal view 6.0 mm x 6.4 mm (F78345). 6. Paratype, apertural view 5.3 mm x 5.6 mm (F78346a). 7. Holotype, apertural view 5.7 mm x 5.4 mm (F78344). 8. Paratype, left lateral view 4.0 mm x 6.4 mm (F78346b). Locality 25. Figs 9-12. *Bellerophon* (*Bellerophon*) *kyndalynensis* n.sp. 9. Holotype, anterior dorsal view 1.2 mm x 1.2 mm (F78348). 10. Paratype, right lateral view, largest diameter, 1.5 mm (F78349b). 11. Paratype, apertural view 1.2 mm x 1.4 mm (F78349a). 12. Selenizone of Fig. 9. Locality 24. Bar scale 0.1 mm.



**Plate 2.** Figs 1-3. *Knightites (Retispira) triangularis* n.sp. 1. Holotype, anterior dorsal view 7.3 mm x 8.6 mm (F78351). 2. Paratype, anterior dorsal view 6.4 mm x 7.1 mm (F78352). 3. Shell and selenizone ornamentation of holotype. Locality 25. Figs 4-7. *Knightites (Retispira) multilirata* n.sp. 4. Holotype, anterior dorsal view 5.2 mm x 7.0 mm (F78353). 5. Paratype, anterior dorsal view 5.3 mm x 6.1 mm (F78354). 6. Paratype, right lateral view, maximum diameter 6.3 mm (F78355). 7. Shell and selenizone ornamentation of paratype. Locality 25. Figs 8-10. '*Serpulospira*' *scalariformis* n.sp. 8. Paratype, apertural view 2.8 mm x 1.0 mm (F78357). 9. Paratype, apertural view 1.4 mm x 0.4 mm (F78358a). 10. Paratype, umbilical view 1.3 mm x 0.4 mm (F78358b). Locality 28. Bar scale 1 mm.

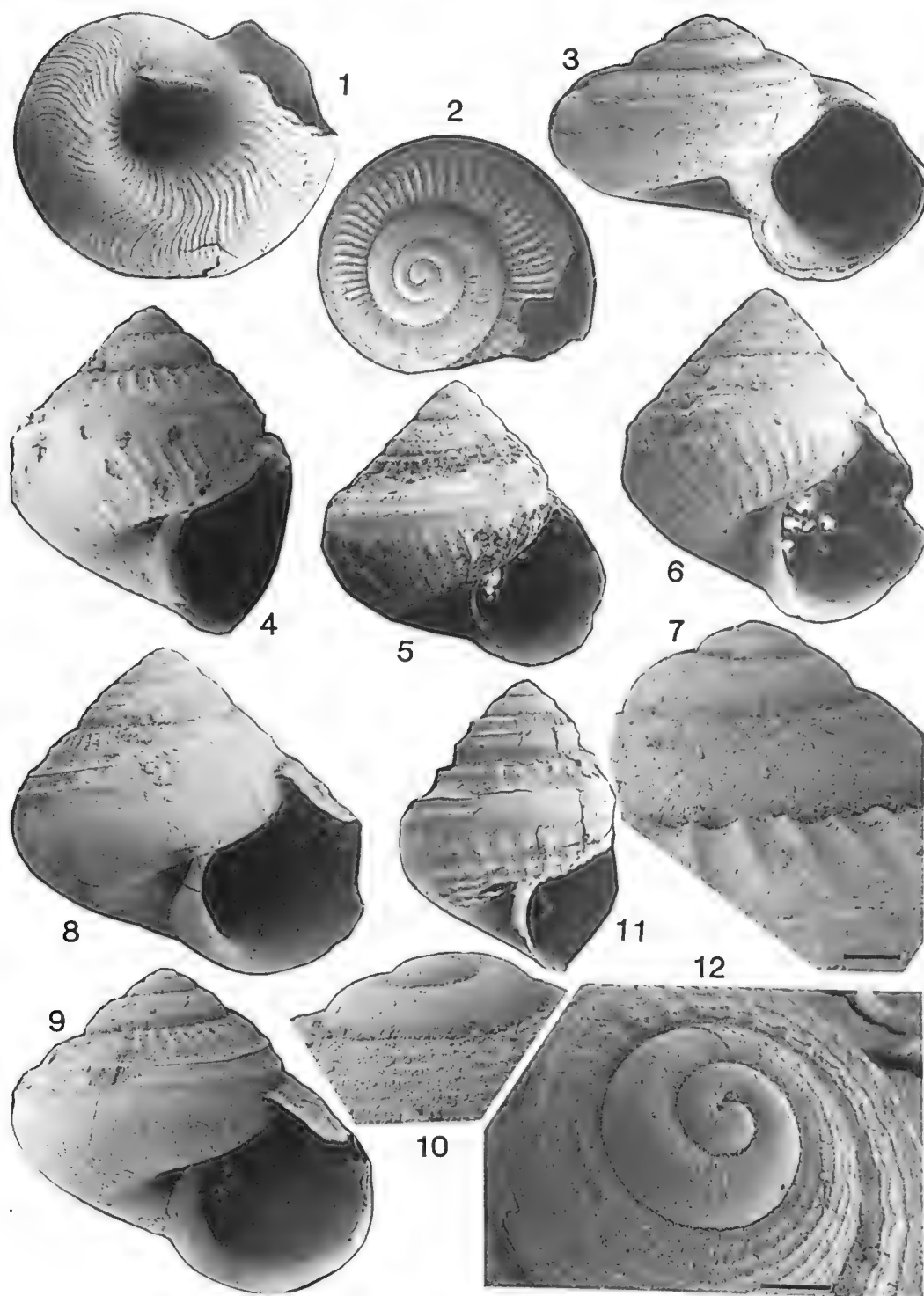


**Plate 3.** Figs 1-5. '*Serpulospira*' *scalariformis* n.sp. 1. Paratype, umbilical view 2.1 mm x 0.6 mm (F78359). 2. Holotype, apical view 2.3mm x 0.8mm (F78360). 3. Paratype, apical view, maximum diameter 2.9 mm (F78361). 4. Paratype, apical view 1.3 mm x 0.3 mm (F78362). 5. Protoconch of Fig. 4. Locality 28. Figs 6-8. *Straparollus brevis* n.sp. 6. Paratype, apertural view 2.3 mm x 1.4 mm (F78364b). 7. Holotype, apertural view 2.2 mm x 1.2 mm (F78363). 8. Paratype, apical view, maximum diameter 1.9 mm (F78364a). Locality 24. Figs 9-12. *Platyschisma vitrea* n.sp. 9. Holotype, apical view, maximum diameter 2.5 mm (F78366). 10. Paratype, umbilical view, maximum diameter 2.1 mm (F78367a). 11. Paratype, apertural view 1.0 mm x 1.3 mm (F78367b). 12. Protoconch of holotype. Locality 28. Bar scale 0.1 mm.

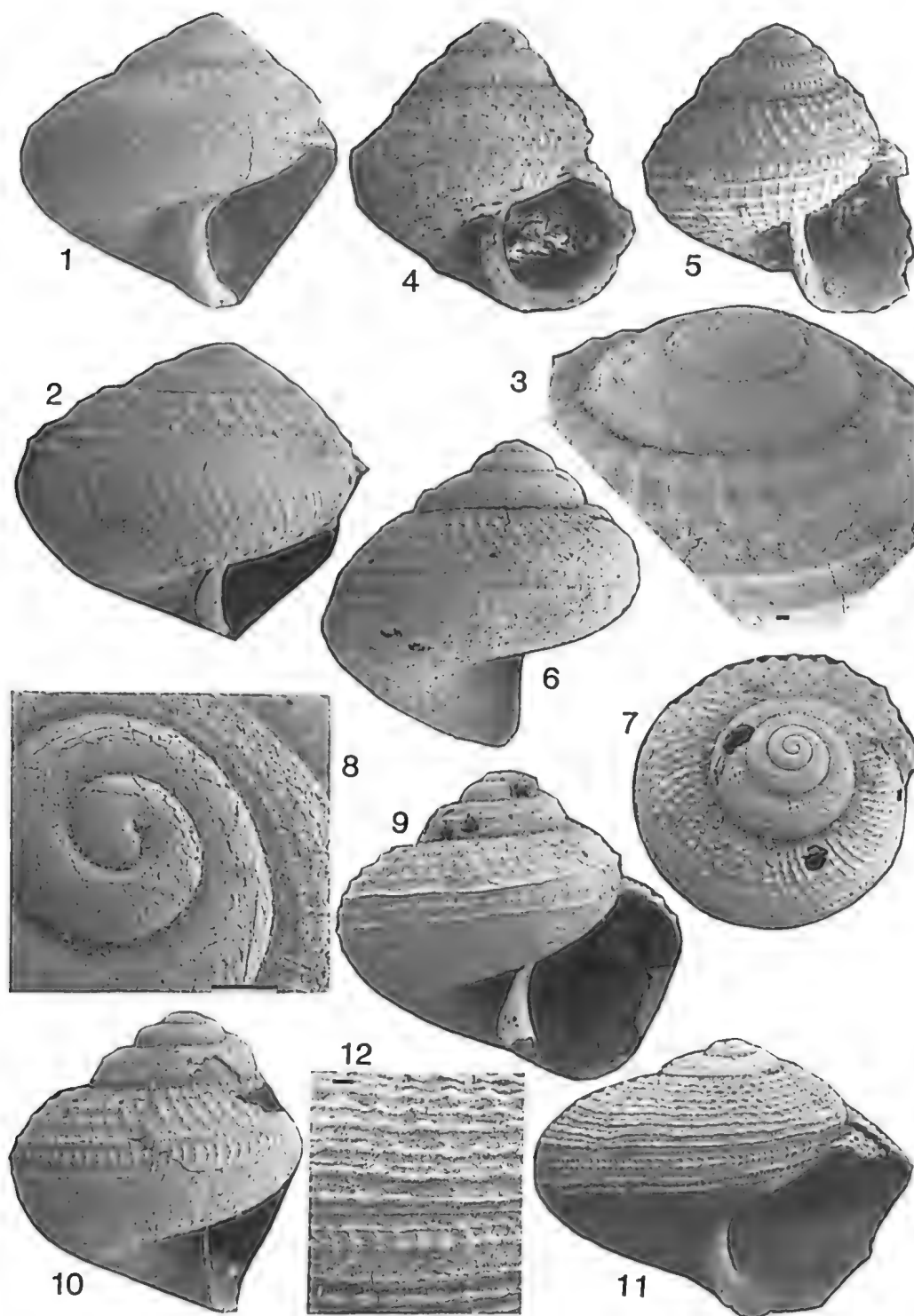


**Plate 4.** Figs 1-3. *Platyschisma lingua* n.sp. 1. Paratype, apertural view 2.8 mm x 3.1 mm (F78370). 2. Holotype, apertural view 2.4 mm x 2.7 mm (F78369). 3. Paratype, apertural view 4.9 mm x 5.0 mm (F78371). Localities 30, 18 and 25. Figs 4-10. *Angyomphalus radianodosa* n.sp. 4. Paratype, apertural view 2.5 mm x 3.9 mm (F78373). 5. Figured specimen, apical view (F78374). 6. Paratype, umbilical view, maximum diameter 3.2 mm (F78375). 7. Paratype, apical view, maximum diameter 3.8 mm (F78376a) 8. Holotype, apertural view 2.5 mm x 3.9 mm (F78372). 9. Paratype, umbilical view, maximum diameter 3.2 mm (F78376). 10. Paratype, apical view, maximum diameter 3.4 mm (F78376b). Locality 28.

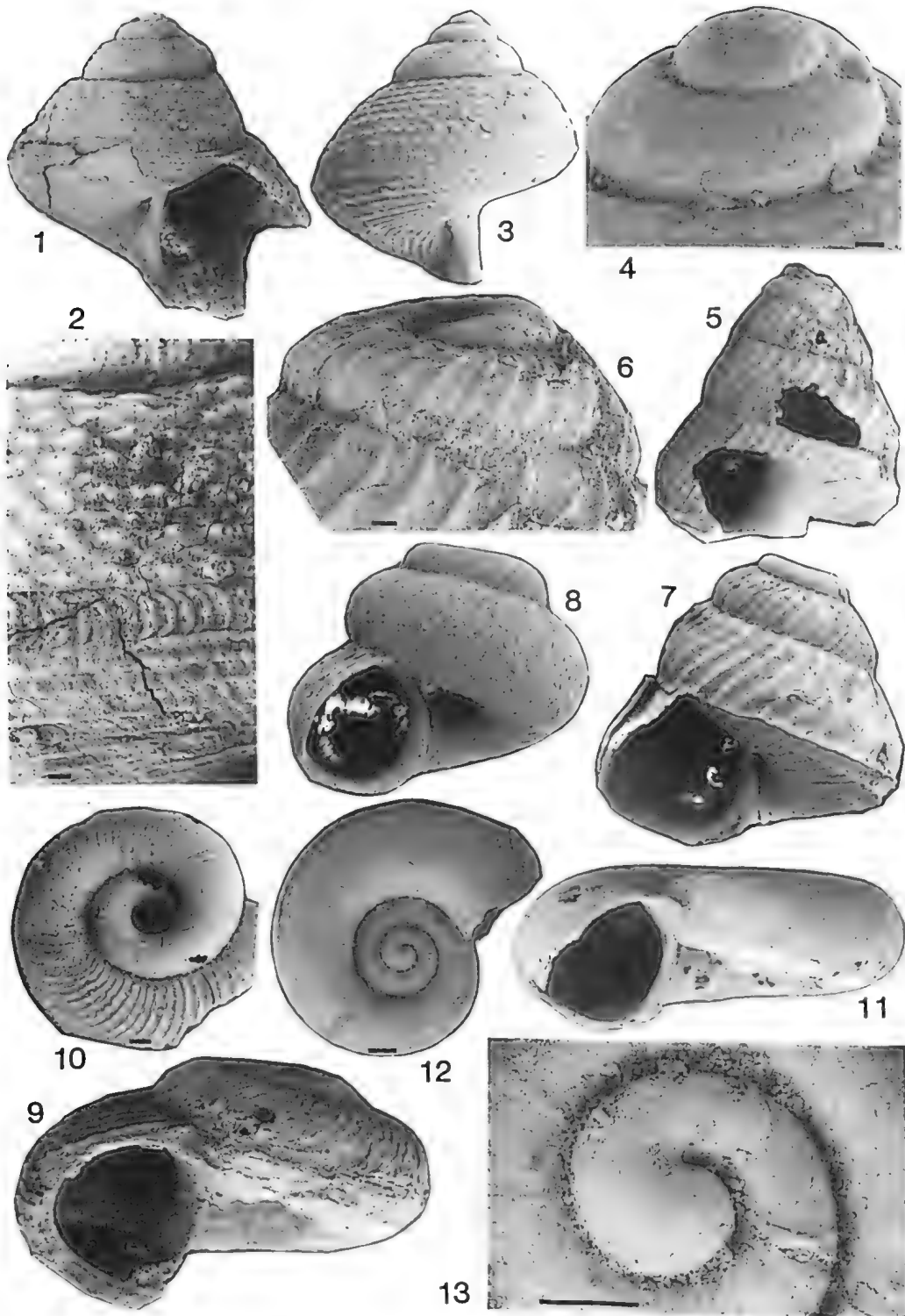




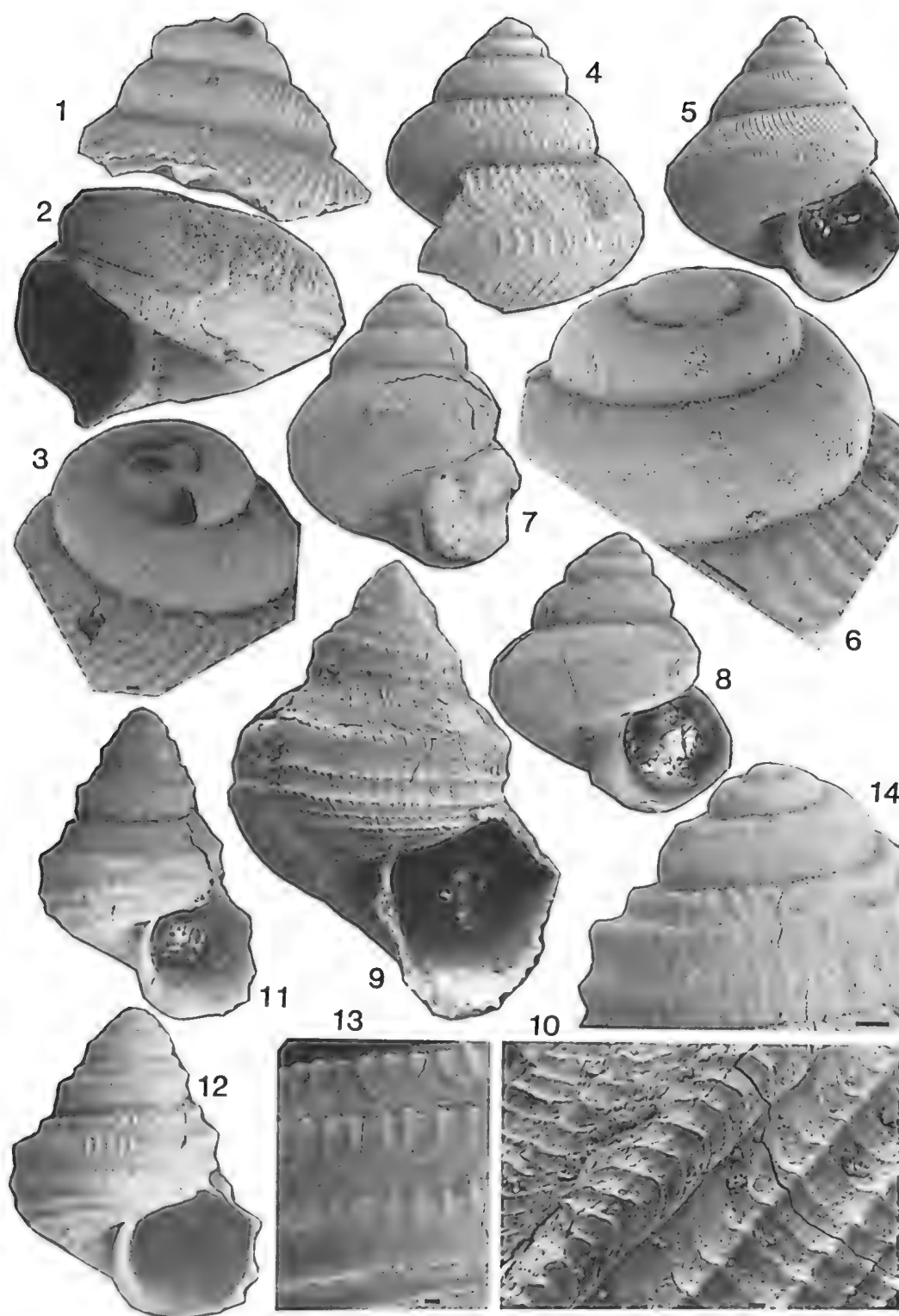
**Plate 5.** Figs 1-3. *Eotomaria umbilicata* n.sp. 1. Paratype, umbilical view, maximum diameter 2.5 mm (F78380a). 2. Paratype, apical view, maximum diameter 1.9 mm (F78380b). 3. Holotype, apertural view 1.6 mm x 2.2 mm (F78379). Locality 28. Figs 4-7. *Campbellospira conica* n.gen., n.sp. 4. Paratype, apertural view, height 3.6 mm (F78383). 5. Holotype, apertural view 4.3 mm x 4.2 mm (F78382). 6. Paratype, apertural view 3.8 mm x 3.5 mm (F78384). 7. Protoconch and early stage of teleoconch of Fig. 4. Locality 25. Figs 8-10. *Campbellospira* sp. A. 8. Apertural view 3.4 mm x 3.8 mm (F78385). 9. Apertural view 2.7 mm x height 2.7 mm (F78387). 10. Protoconch of Fig. 9. Locality 25. Figs 11-12. *Campbellospira* sp. B. 11. Apertural view 3.0 mm (F78386). 12. Protoconch and early stage of teleoconch of Fig. 11. Locality 25. Bar scale 0.1 mm.



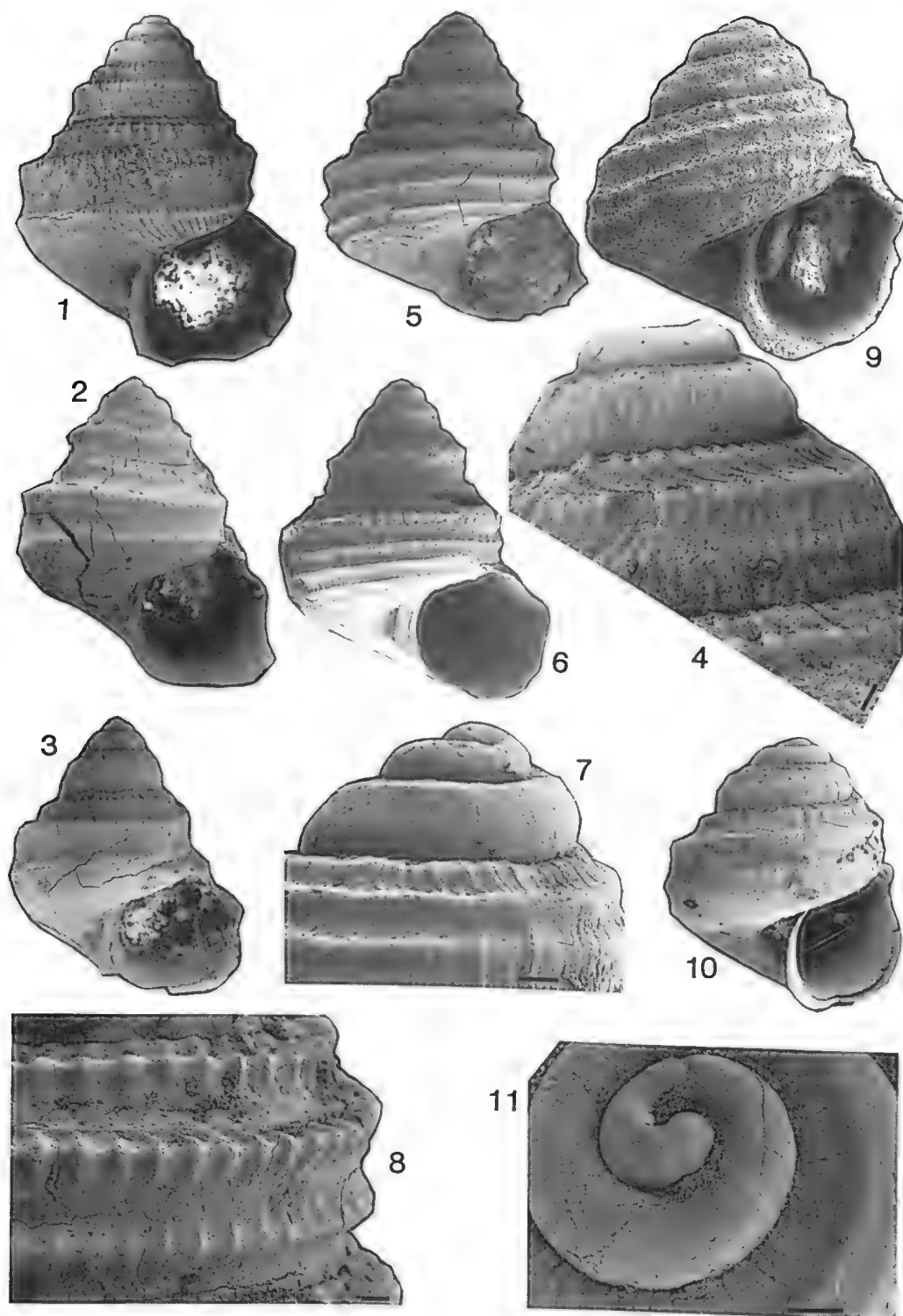
**Plate 6.** Figs 1-3. *Campbellospira* sp. C. 1. Apertural view 3.0 mm x 3.1 mm (F78388). 2. Apertural view 3.1 mm x 3.5 mm (F78389). 3. Protoconch and early stage of teleoconch of Fig. 2. Locality 25. Figs 4-10. *Glabrocingulum obesum* Yoo. 4. Apertural view 5.0 mm x 5.0 mm (F78393). 5. Apertural view 3.2 mm x 2.6 mm (F78395). 6. Apertural view 2.3 mm x 2.4 mm (F78394b). 7. Apical view (F78394). 8. Protoconch of Fig. 7. 9. Apertural view 2.2 mm x 2.5 mm (F78394c). 10. Apertural view 1.5 mm x 1.5 mm (F78394a). Locality 28. Figs 11-12. *Glabrocingulum* sp. 11. Apertural view 3.5 mm x 3.7 mm (F78396). 12. Selenizone ornamentation of Fig. 11. Locality 25. Bar scale 0.1 mm.



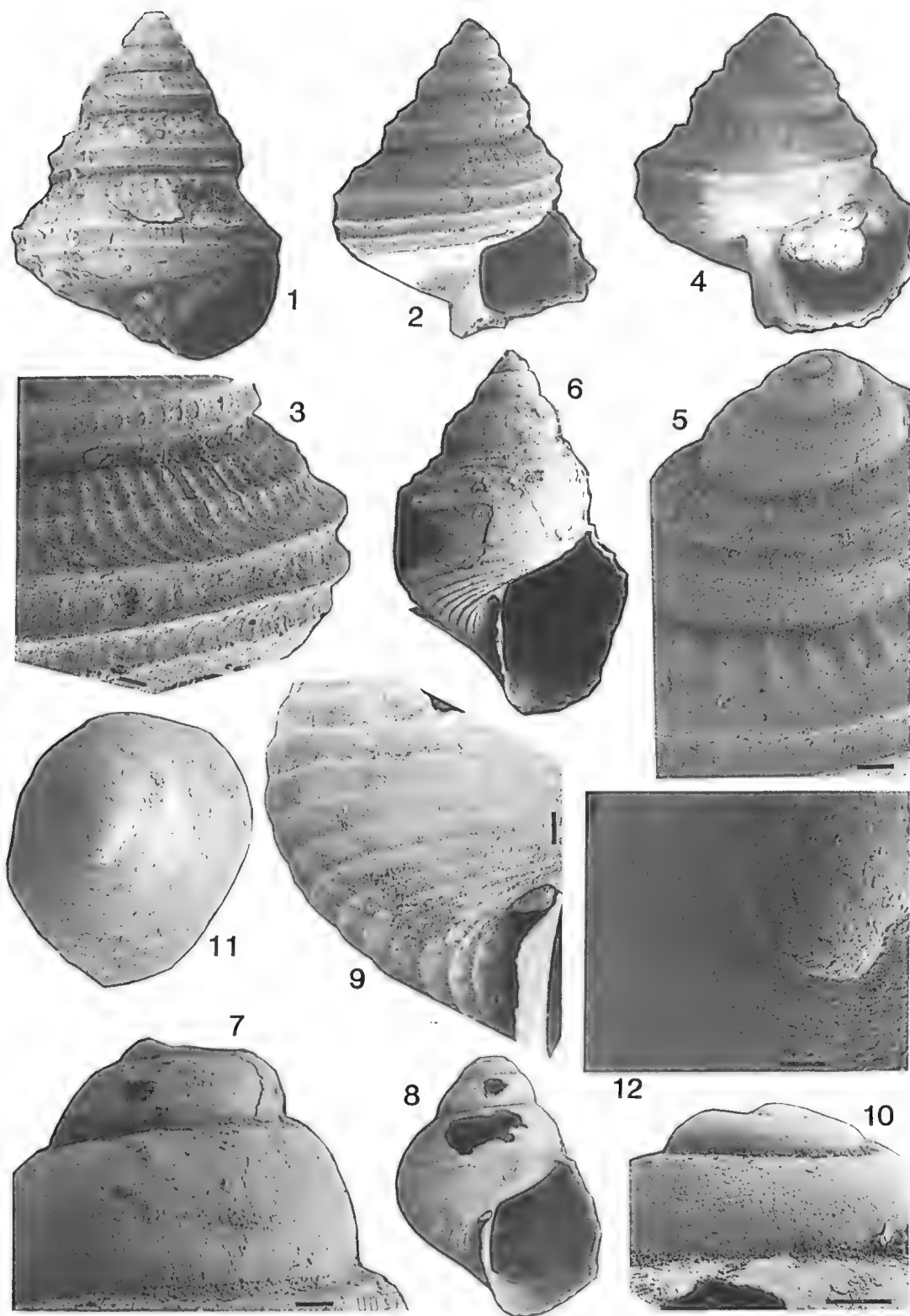
**Plate 7.** Figs 1-4. *Glabrocingulum pustulum* n.sp. 1. Holotype, apertural view 5.6 mm x 5.5 mm (F78397). 2. Selenizone and last whorl ornamentation of holotype. 3. Paratype, apertural view 5+ mm x 5+ mm (F78398). 4. Protoconch of Fig. 3. Locality 25. Figs 5-7. *Hesperrella elongata* n.sp. 5. Holotype, apertural view 4.1 mm x 3.7 mm (F78399). 6. Apex of holotype, protoconch hidden. 7. Apertural view, immature 2.5 mm x 2.7 mm (F78400). Localities 18 (Fig. 5) and 29 (Fig. 7). Fig. 8. *Hesperrella robertsi* Yoo. Apertural view of juvenile 1.7 mm x 1.8 mm (F78401). Locality 31. Figs 9-13. *Hesperrella planorbis* n.sp. 9. Holotype, apertural view 1.7 mm x 2.6 mm (F78402). 10. Paratype, apical view, protoconch sunken (F78403). 11. Paratype, apertural view 0.8 mm x 1.3 mm (F78403). 12. Paratype, umbilical view, protoconch visible (F78403). 13. Protoconch of Fig. 12. Locality 28. Bar scale 0.1 mm.



**Plate 8.** Figs 1-3. *Agnesia reticulata* n.sp. 1, 2. Shell broken, width of last whorl 7.1 mm (F78406). 3. Oblique apical view of Fig. 1, protoconch sunken and early stage of teleoconch broken. Locality 25. Figs 4-8. *Peruvispira gundyensis* Yoo. 4. Figured specimen, side view 2.3 mm x 2.1 mm (F78407). 5. Apertural view 4.1 mm x 3.4 mm (F78408). 6. Protoconch and early stage of teleoconch of Fig. 5. 7. Apertural view 2.8 mm x 2.1 mm (F78409a). 8. Apertural view 2.9 mm x 2.4 mm (F78409b). Localities 25 (Fig. 5) and 31 (Figs 4, 7, 8). Figs 9-10. *Ruedemannia* sp. 9. Apertural view 9.7 mm x 7.1 mm (F78411). 10. Teleoconch and selenizone ornamentation of Fig. 9. Locality 25. Figs 11-14. *Worthenia crenilunula* n.sp. 11. Paratype, apertural view 6.6 mm x 4.4 mm (F78413b). 12. Paratype, apertural view 4.5 mm x 3.6 mm (F78413a). 13. Teleoconch and selenizone ornamentation of Fig. 12. Locality 25. Bar scale 0.1 mm.

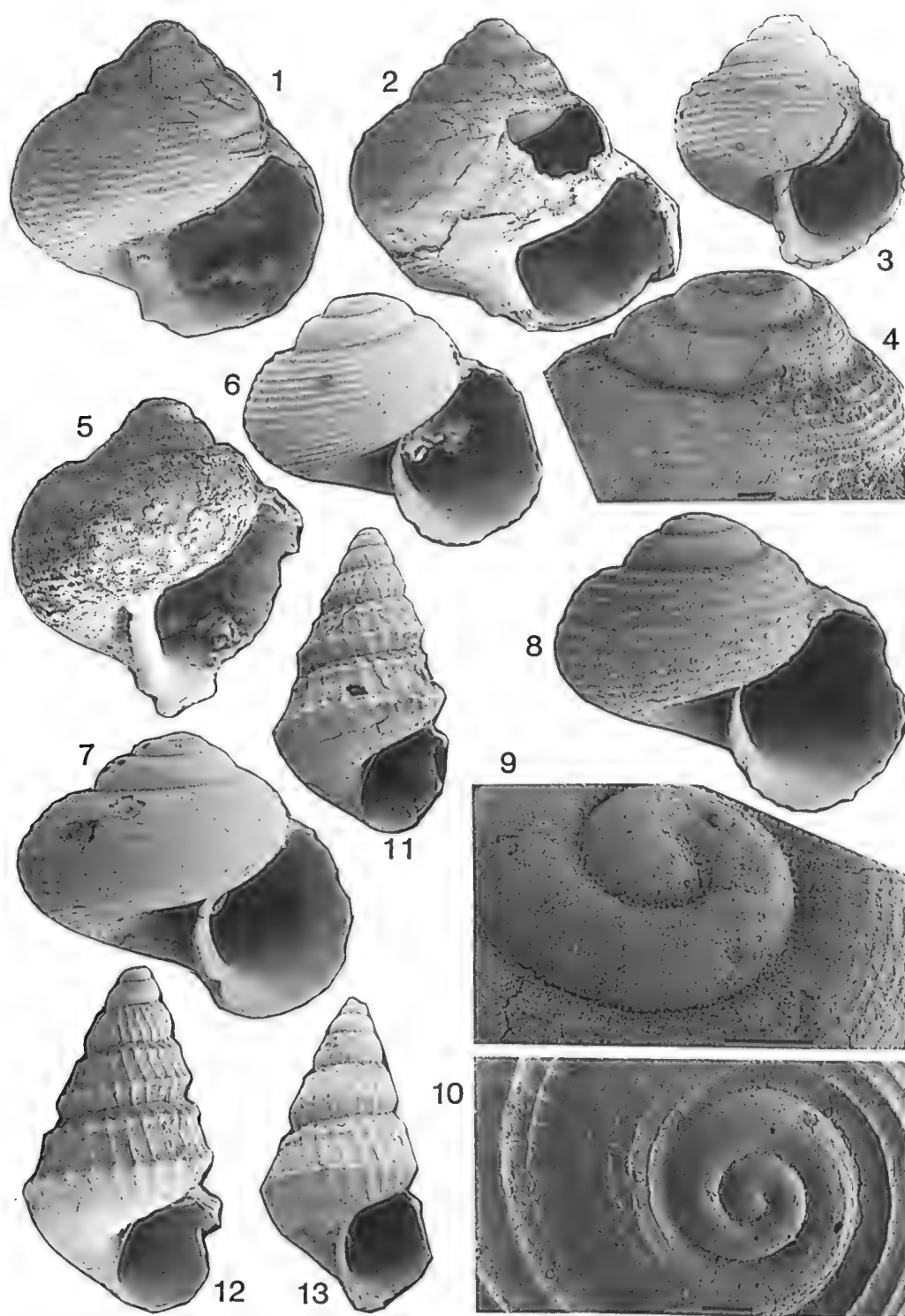


**Plate 9.** Figs 1-4. *Ruedemannia* sp. 1. Apertural view 6.3 mm x 4.4 mm (F78414). 2. Apertural view 5.2 mm x 4.4 mm (F78417). 3. Apertural view 3.8 mm x 3.1 mm (F78418). 4. Protoconch and early stage of teleoconch of Fig. 1. Locality 25. Figs 5-8. *Worthenia crenilunula* n.sp. 5. Paratype, apertural view 4.9 mm x 3.9 mm (F78415). 6. Holotype, apertural view 6.4 mm x 4.9 mm (F78419). 7. Protoconch and early stage of teleoconch of Fig. 6. 8. Teleoconch and selenizone ornamentation of Fig. 6. Localities 25 (Fig. 5) and 18 (Fig. 6). Figs 9-11. *Worthenia* sp. 9. Apertural view 1.8 mm x 1.7 mm (F78421). 10. Apertural view 2.1 mm x 1.8 mm (F78420). 11. Protoconch and early stage of teleoconch of Fig. 10. Localities 30 (Fig. 9) and 31 (Fig. 10). Bar scale 0.1 mm.



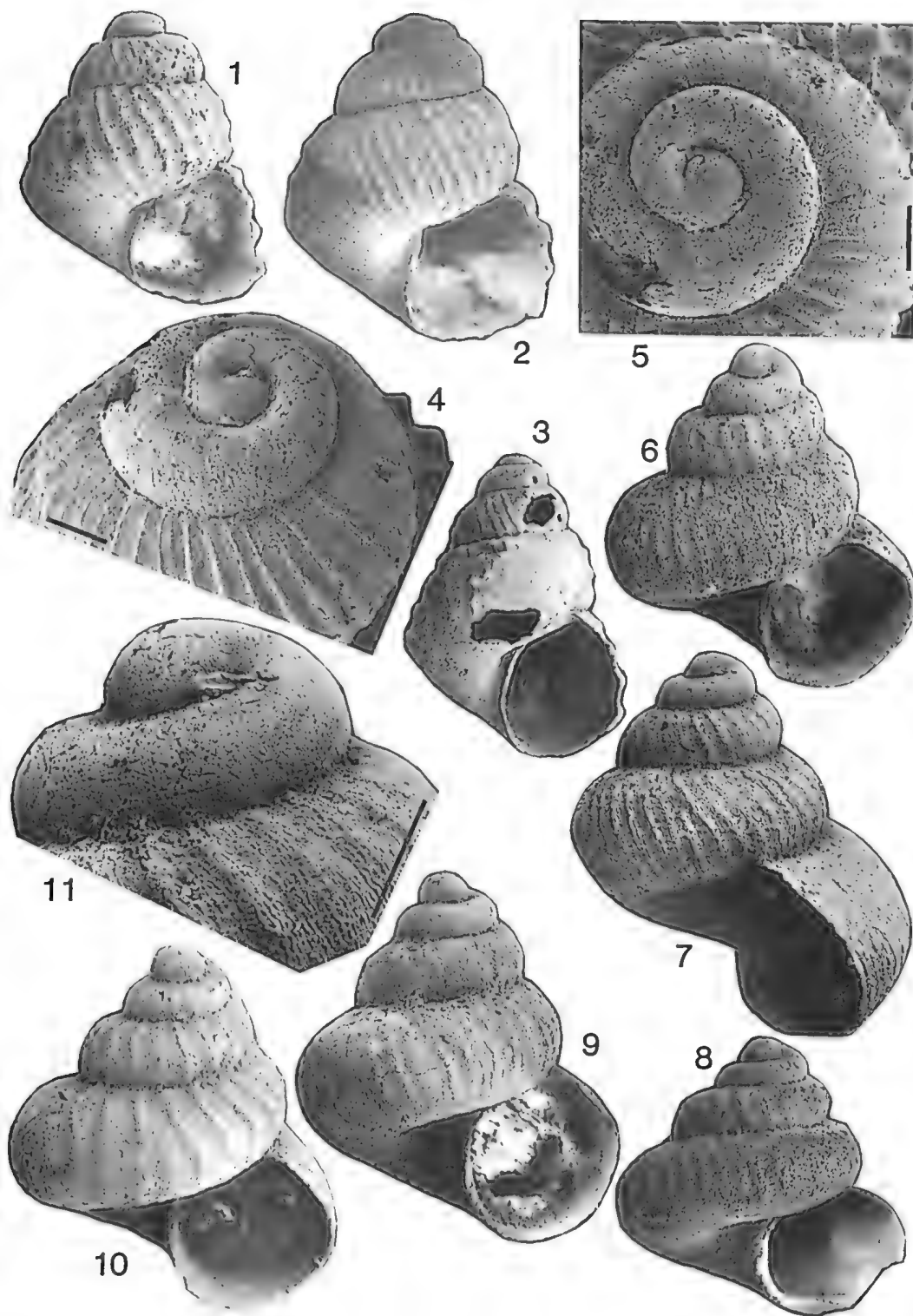
**Plate 10.** Figs 1-5. *Borestus costatus* Yoo. 1. Apertural view 6.6 mm x 5.0 mm (F78422). 2. Apertural view 2.7 mm x 2.1 mm (F78423). 3. Teleoconch and selenizone ornamentation of Fig. 2. 4. Apertural view 3.9 mm x 3.4 mm (F78424). 5. Protoconch and early stage of teleoconch of Fig. 4. Localities 25 (Figs 1, 4, 5) and 31 (Figs 2, 3). Figs 6-10. *Gyronema nacreformis* n.sp. 6. Holotype, apertural 5.4 mm x 3.6 mm (F78425). 7. Protoconch of holotype. 8. Paratype, apertural view 2.7 mm x 2.2 mm (F78426). 9. Base and umbilicus of Fig. 8. 10. Protoconch of Fig. 8. Locality 25. Figs 11-12. '*Lepetopsis*' sp. 11. Apical view, maximum diameter of shell 1.4 mm (F78428). 12. Protoconch of Fig. 11. Locality 28. Bar scale 0.1 mm.



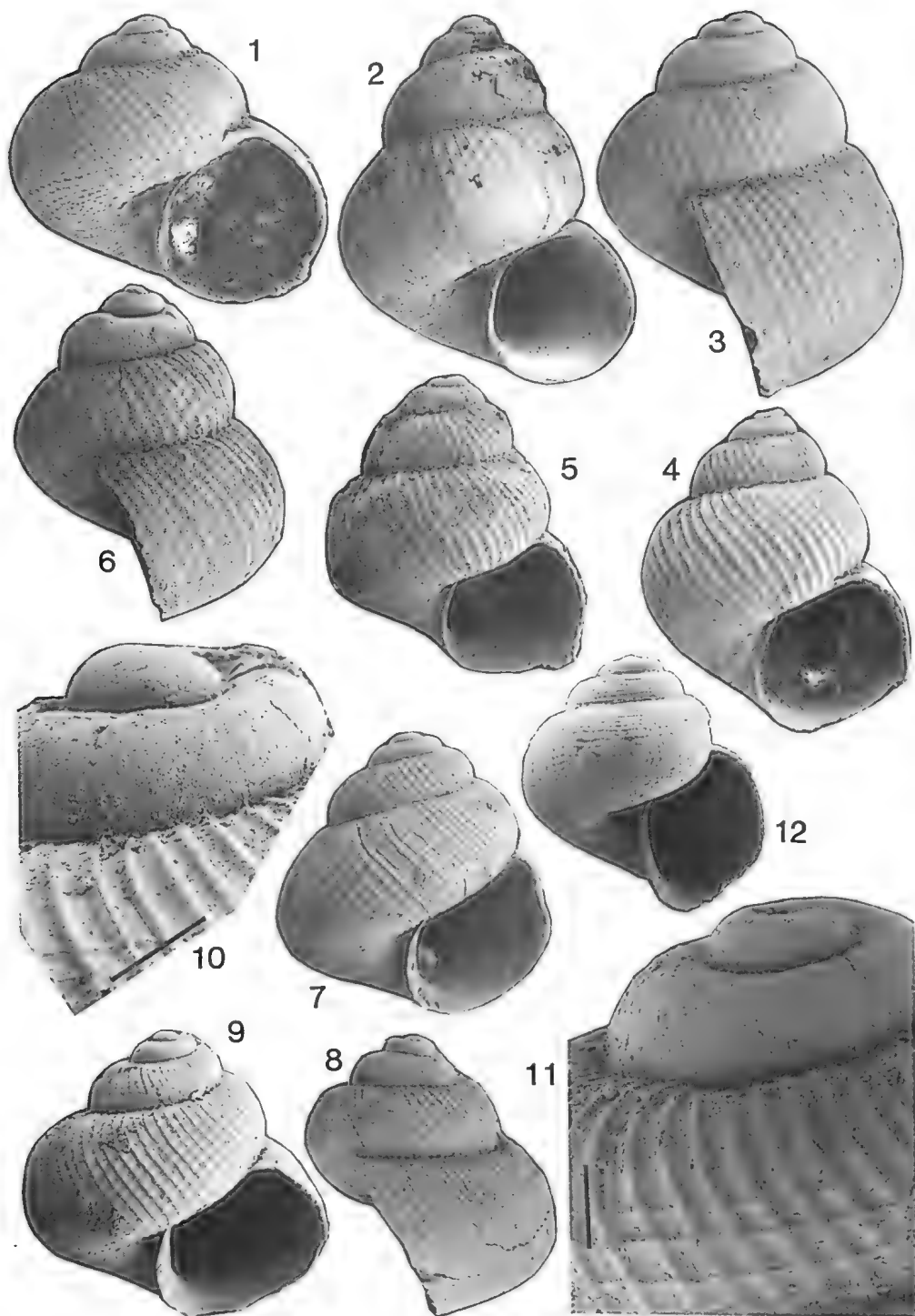


**Plate 11.** Figs 1-10. *Rhabdotocochlis turgida* n.sp. 1. Paratype, apertural view 2.9 mm x 2.9 mm (F78429b). 2. Paratype, apertural view 5.0 mm x 5.2 mm (F78429a). 3. Holotype, apertural view 4.9 mm x 4.7 mm (F62002). 4. Protoconch and early stage of teleoconch of Fig. 2. 5. Paratype, apertural view 3.5 mm x 3.4 mm (F78430). 6. Figured specimen, juvenile apertural view 1.6 mm x 1.6 mm (F78431). 7. Figured specimen, juvenile apertural view 1.7 mm x 1.9 mm (F78432). 8. Figured specimen, juvenile apertural view 1.8 mm x 2.0 mm (F78432). 9. Protoconch and early stage of teleoconch of Fig. 2. 10. Protoconch and early stage of teleoconch of Fig. 8. Localities 18 (Figs 1, 5), 28 (figs 6, 8) and 32 (figs 3, 5). Figs 11-13. *Microdoma angulata* Yoo. 11. Figured specimen, apertural view 3.5 mm x 2.2 mm (F78434a). 12. Apertural view 2.6 mm x 1.4 mm (F78434b). 13. Apertural view 3.1 mm x 1.9 mm (F78434c). Locality 28. Bar scale 0.1 mm.

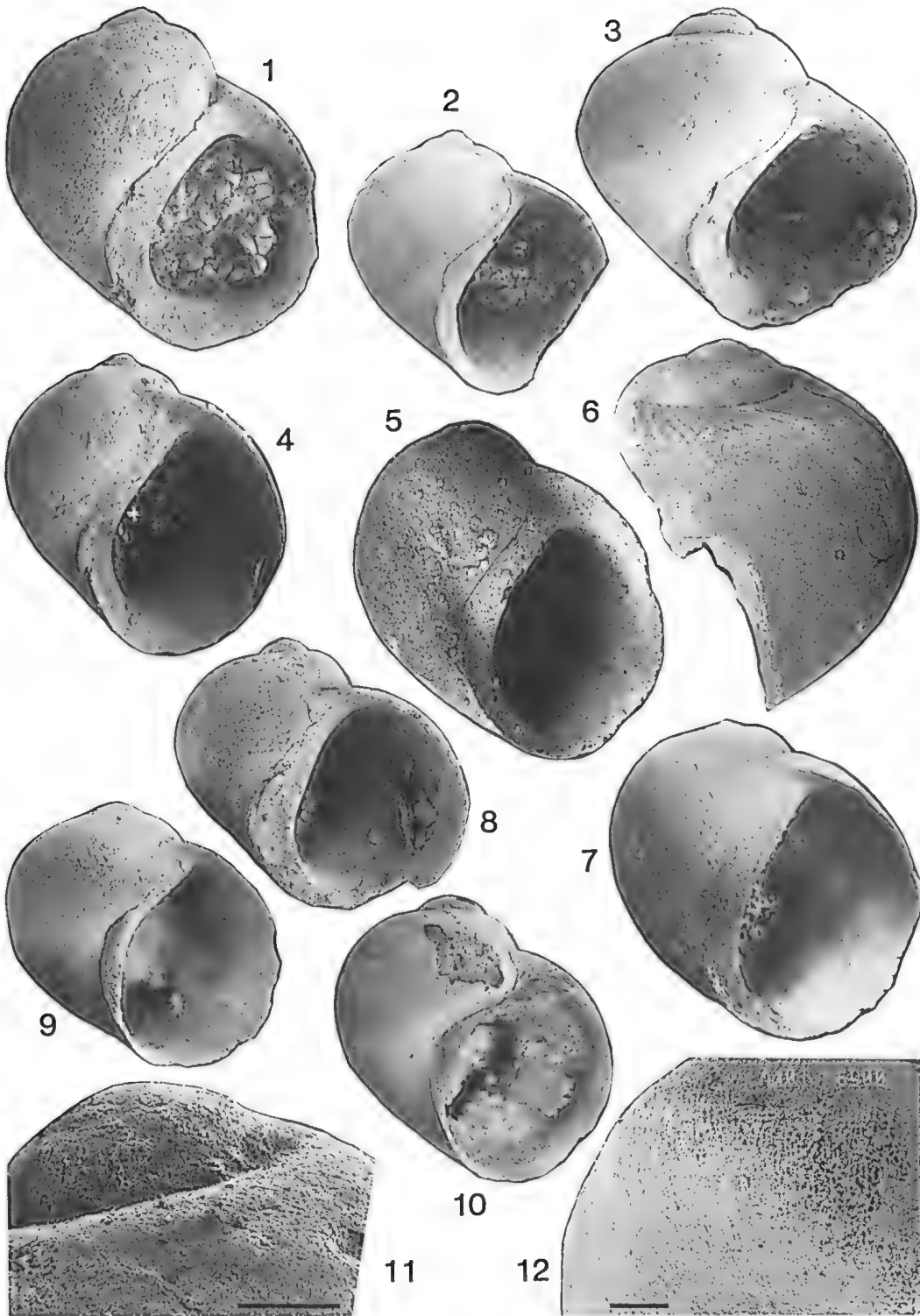




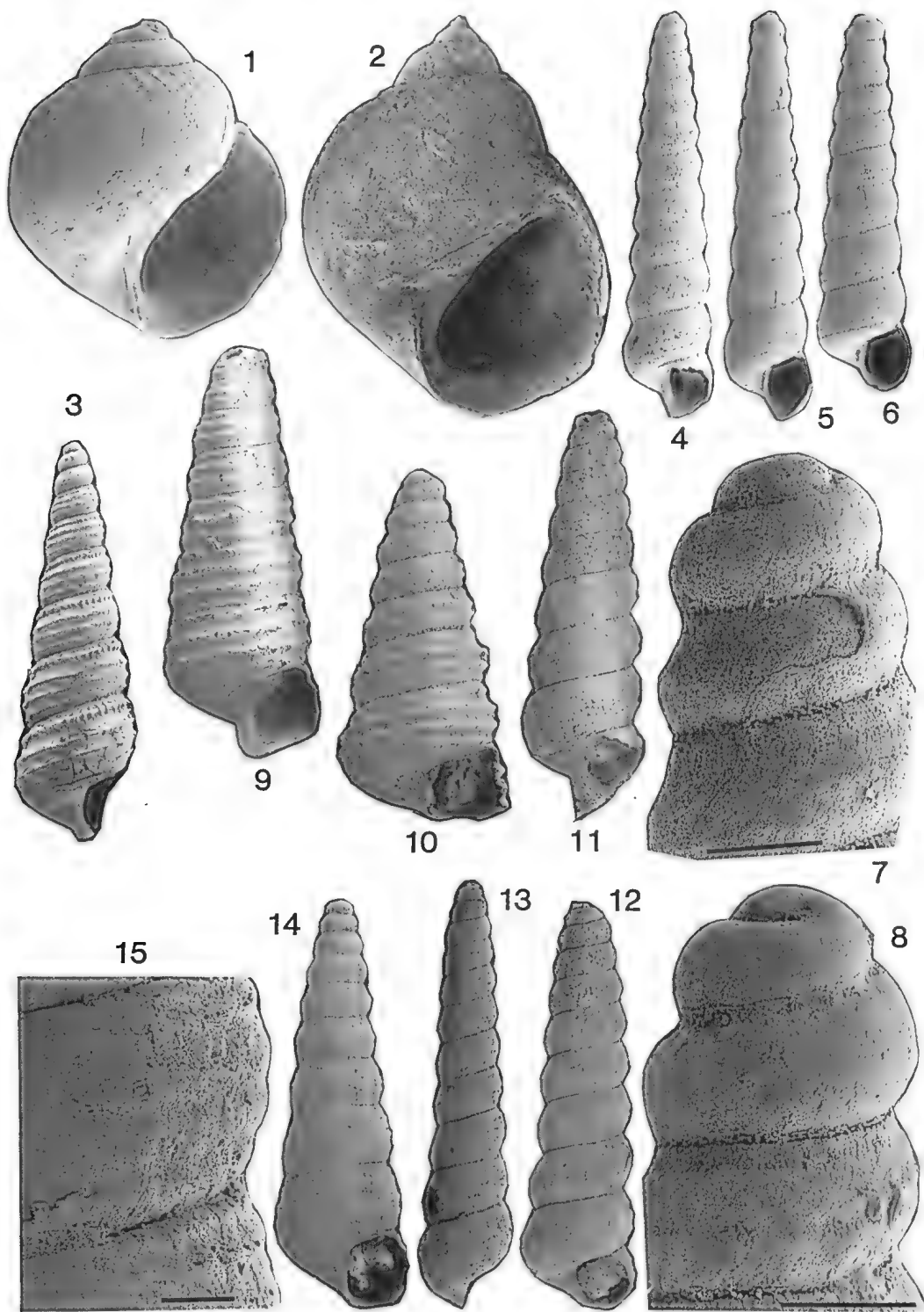
**Plate 12.** Figs 1-5. *Microcochlis parva* n.gen., n.sp. 1. Paratype, apertural view 1.4 mm x 1.2 mm (F78438a). 2. Paratype, apertural view 1.3 mm x 1.0 mm (F78438b). 3. Holotype, apertural view 2.1 mm x 1.5 mm (F78437). 4. Oblique apical view, protoconch and early stage of teleoconch of Fig. 1. 5. Apical view. Locality 24. Figs 6-11. *Kyndalynia inflata* n.gen., n.sp. 6. Paratype, apertural view, slightly tilted forward 1.1 mm x 1.0 mm (F78441a). 7. Holotype, side view, height 1.3 mm (F78440). 8. Paratype, apertural view 1.0 mm x 1.0 mm (F78442). 9. Paratype, apertural view 1.2 mm x 1.0 mm (F78443). 10. Paratype, apertural view, slightly tilted forward 1.1 mm x 1.0 mm (F78441b). 11. Protoconch of holotype. Locality 24. Bar scale 0.1 mm.



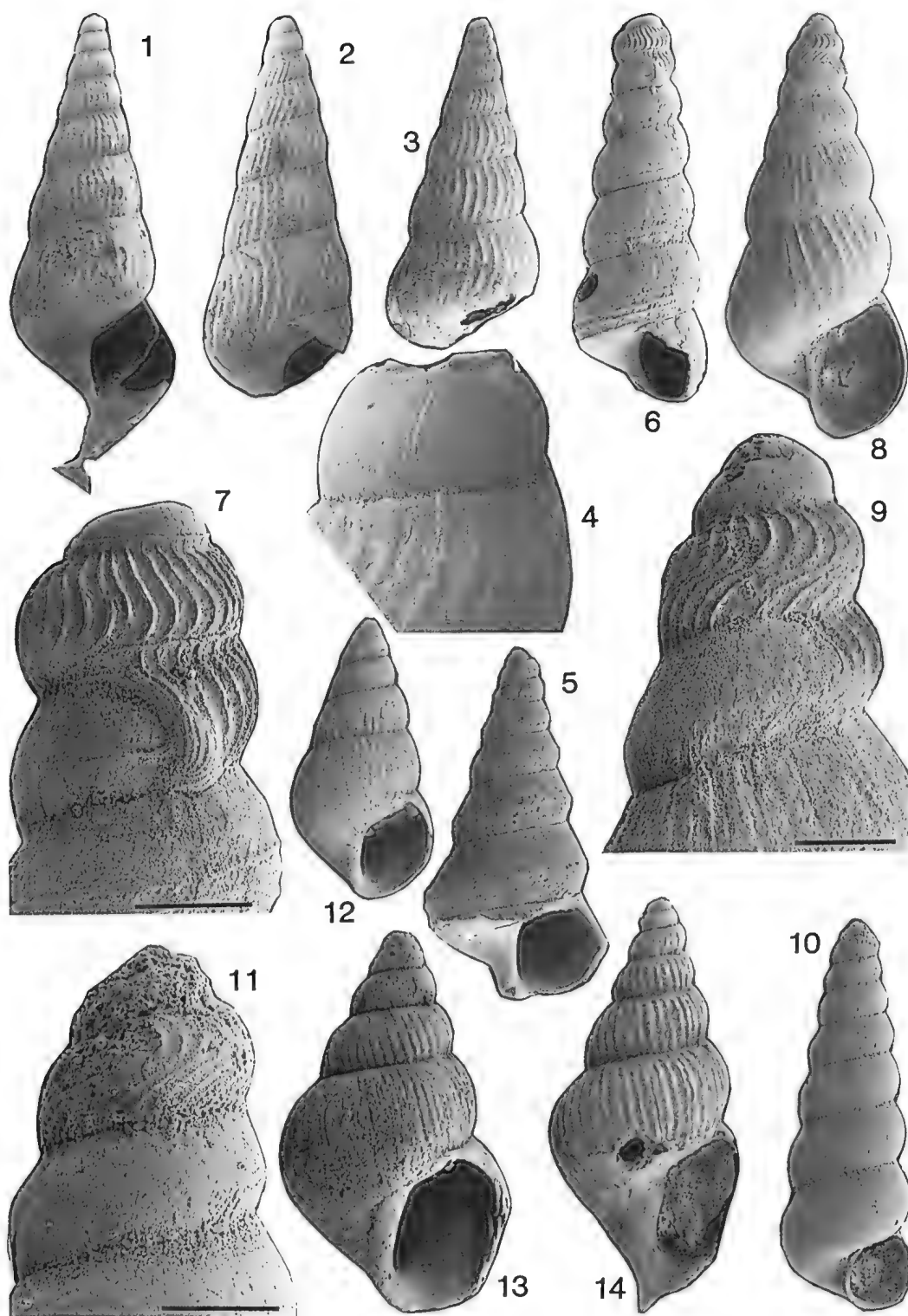
**Plate 13.** Fig. 1. *Eucochlis* sp. Apertural view 1.6 mm x 1.8 mm (F78445). Locality 31. Figs 2-3. *Eucochlis australis* Yoo. 2. Apertural view 2.2 mm x 1.5 mm (F78446). 3. Side view 1.4 mm x 0.8 mm (F78447). Locality 28. Figs 4-6. *Eucochlis umbiliparva* n.sp. 4. Holotype, apertural view 1.7 mm x 1.7 mm (F78448). 5. Paratype, apertural view 1.8 mm x 1.5 mm (F78449). 6. Paratype, side view, height 1.8 mm (F78450). Localities 31 (Fig. 4), 28 (Fig. 5) and 29 (Fig. 6). Figs 7-11. *Eucochlis depressa* n.sp. 7. Holotype, apertural view 1.6 mm x 1.5 mm (F78451). 8. Paratype, side view showing strong prosocline outer lip 1.6 mm x 1.4 mm (F78452). 9. Paratype, apertural view 1.6 mm x 1.6 mm (F78453). 10. Protoconch of Fig. 9. 11. Protoconch and early stage of teleoconch of holotype. Locality 25. Fig. 12. *Araeonema microspirulata* Yoo. Holotype, apertural view 1.2 mm x 1.1 mm (F61958). Locality 28. Bar scale 0.1 mm.



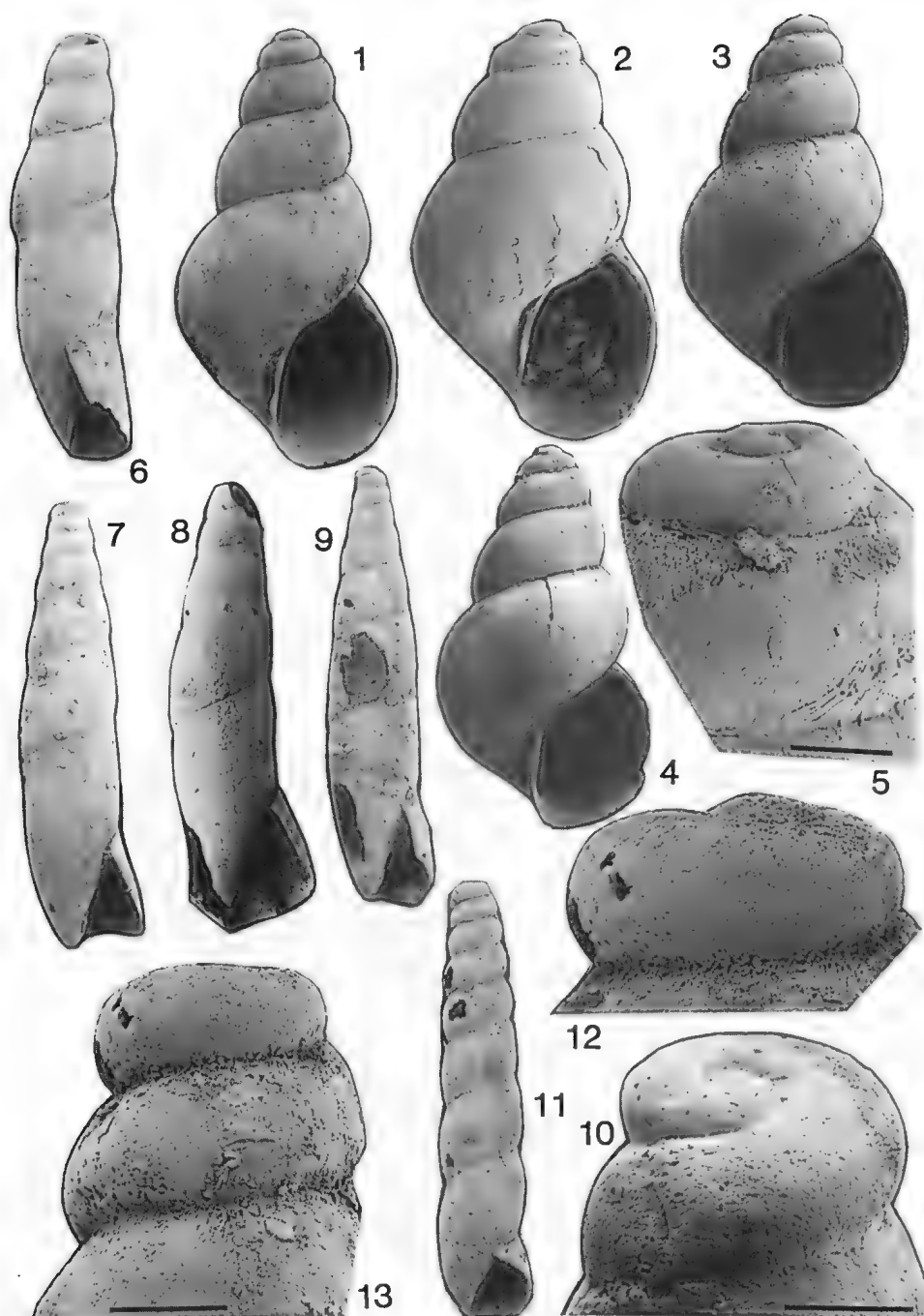
**Plate 14.** Figs 1-8. *Naticopsis (Naticopsis) osbornei* Yoo. 1. Apertural view 2.8 mm x 2.4 mm (F78457a). 2. Apertural view 3.4 mm x 3.3 mm (F78460). 3. Apertural view 2.1 mm x 2.3 mm (F78457b). 4. Apertural view 3.9 mm x 3.5 mm (F78458). 5. Apertural view 4.5 mm x 3.6 mm (F78459a). 6. Side view, height 4.6 mm (F78459c). 7. Apertural view 6.0 mm x 5.6 mm (F78459b). 8. Apertural view 1.8 mm x 2.0 mm (F78456). Locality 25 except Fig. 8 (Locality 28). Figs 9-12. *Naticopsis (Naticopsis) minuta* n.sp. 9. Holotype, apertural view 1.1 mm x 1.1 mm (F78463). 10. Paratype, apertural view 1.2 mm x 1.1 mm (F78464). 11. Protoconch of Fig. 9. 12. Teleoconch ornamentation of Fig. 9. Locality 24. Bar scale 0.1 mm.



**Plate 15.** Figs 1-2. *Turbonitella* sp. 1. 1. Apertural view 2.6 mm x 2.3 mm (F78465). 2. Apertural view 5.0 mm x 3.7 mm (F78466). Localities 25 (Fig. 2) and 28 (Fig. 1). Fig. 3. *Stegocoelia* (*Stegocoelia*) *nodosa* Yoo. Figured specimen 3.7 mm x 1.2 mm (F78467). Locality 28. Figs 4-8. *Stegocoelia* (*Hypergonia*) *tenuis* Yoo. 4. Figured specimen, height 2.5 mm (F78468). 5. Figured specimen, height 2.4 mm (F78469). 6. Figured specimen, height 2.0 mm (F78470). 7, 8. Protoconchs. Locality 28. Figs 9-10. *Stegocoelia* (*Hypergonia*) sp. A. 9. Figured specimen, height 2.6 mm (F78471). 10. Figured specimen, height 1.8 mm (F78472). Locality 24. Figs 11-15. *Stegocoelia* (*Hypergonia*) sp. B. 11. Aperture broken, height 2.4 mm (F78473). 12. Apertural view, height 2.8 mm (F78473). 13. Aperture broken, height 3.9 mm (F78474). 14. Apertural view, height 2.8 mm (F78475). 15. Teleoconch ornamentation of Fig. 13. Locality 24. Bar scale 0.1 mm.

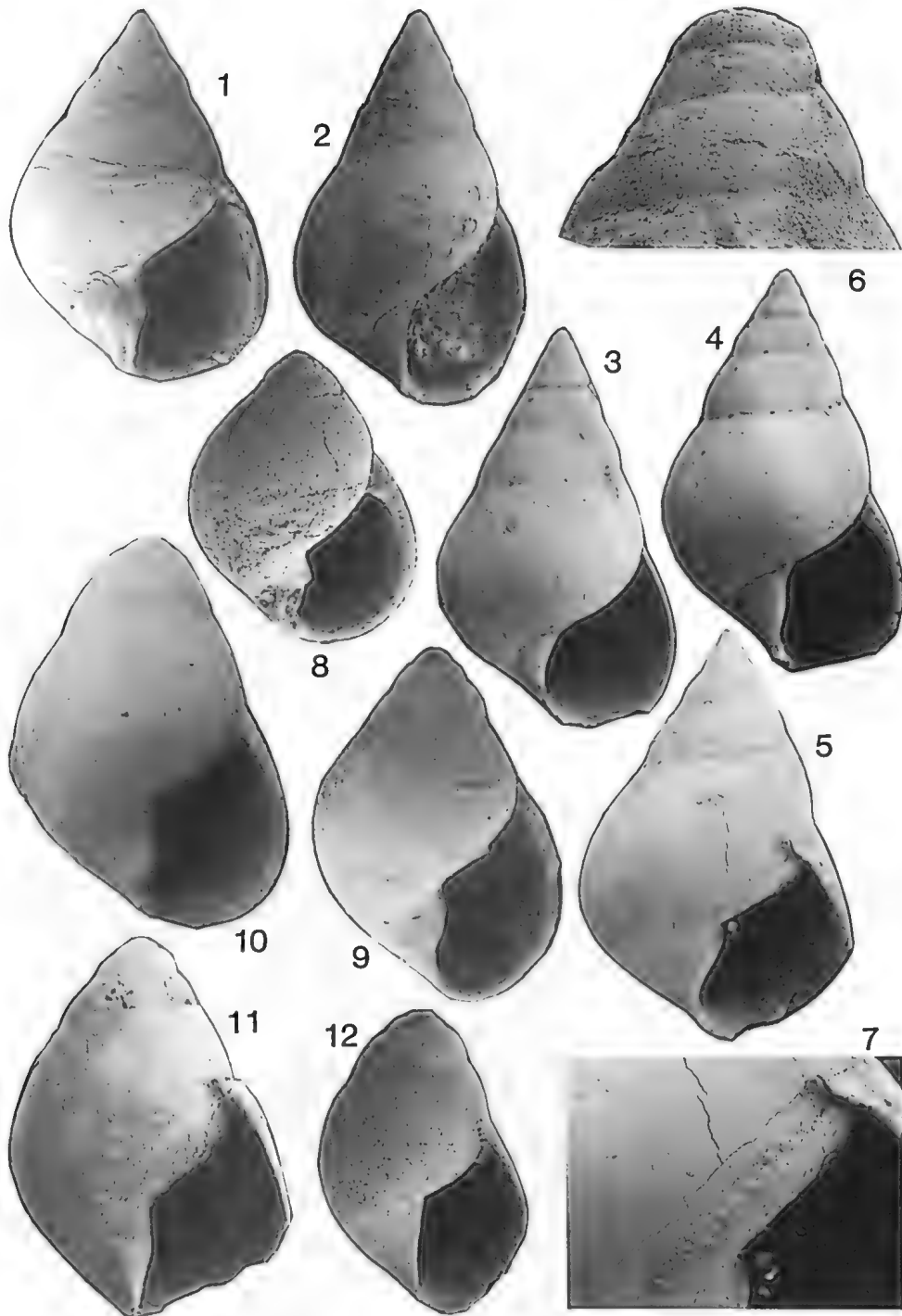


**Plate 16.** Figs 1-4. *Palaeozygopleura obesa* n.sp. 1. Holotype, aperture broken 10+ mm x 3.2 mm (F78477). 2. Paratype, aperture broken 5.6 mm x 2.2 mm (F78478). 3. Paratype, aperture broken 5.2 mm x 2.5 mm (F78479). 4. Protoconch of Fig. 2. Locality 28. Fig. 5. *Murchisonia* sp. Apertural view, aperture broken, height 5.8 mm (F78482). Figs 6-7. *Cyclozyga sinuigera* Yoo. 6. Side view 1.3 mm x 0.4 mm (F78480). 7. Protoconch of Fig. 6. Locality 28. Figs 8-9. *Leptozyga costata* n.sp. 8. Holotype, apertural view 1.6 mm x 0.4 mm (F78481). 9. Protoconch and early stage of teleoconch of holotype. Locality 24. Figs 10-11. *Pseudozygopleura gracilis* n.sp. 10. Holotype, apertural view 1.5 mm x 0.5 mm (F78483). 11. Protoconch and early stage of teleoconch of holotype. Locality 24. Figs 12-14. *Hemizyga decussata* Yoo. 12. Apertural view 3.2 mm x 1.7 mm (F78486). 13. Apertural view 2.3 mm x 1.4 mm (F78485). 14. Apertural view 3.5 mm x 1.7 mm (F78484). Locality 28. Bar scale 0.1 mm.



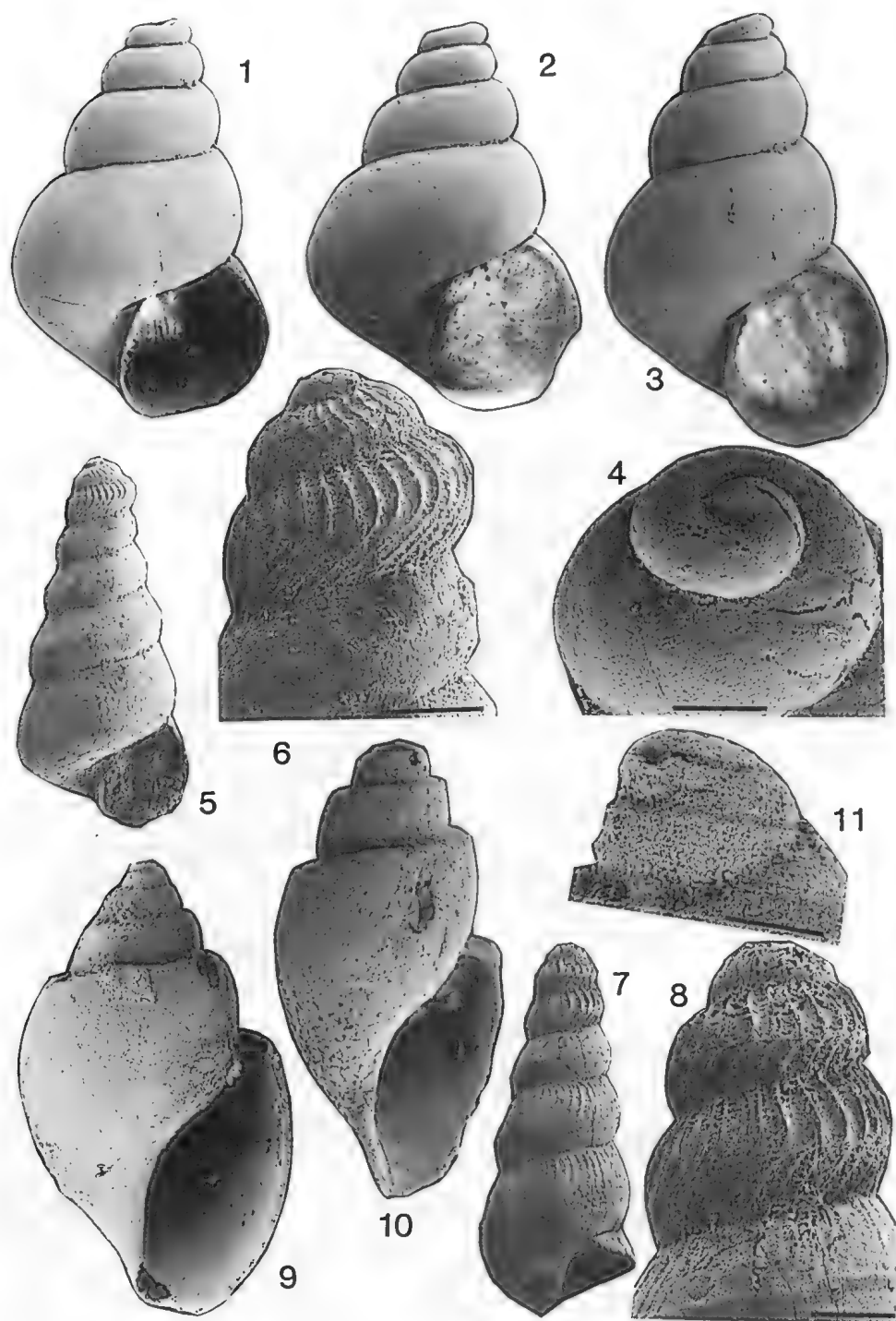
**Plate 17.** Figs 1-5. *Kimina minor* n.gen., n.sp. 1. Holotype, apertural view 5.3 mm x 2.1 mm (F78487). 2. Paratype, apertural view 2.1 mm x 1.2 mm (F78488). 3. Paratype, apertural view 2.0 mm x 1.3 mm (F78489a). 4. Paratype, apertural view 2.2 mm x 1.3 mm (F78489b). 5. Protoconch of Fig. 2. Localities 28 (Figs 1, 3, 4) and 25 (Fig. 2). Figs 6-10. *Ceraunocochlis australis* n.sp. 6. Paratype, apertural view 3.2 mm x 0.8 mm (F78491b). 7. Holotype, apertural view 3.4 mm x 0.8 mm (F78490). 8. Paratype, aperture broken 3.0 mm x 0.7 mm (F78491c). 9. Paratype, apertural view 3.7 mm x 0.8 mm (F78491a). 10. Protoconch of Fig. 8. Locality 28. Figs 11-13. *Ceraunocochlis tenuis* n.sp. 11. Holotype, apertural view 2.3 mm x 0.5 mm (F78494). 12. Protoconch of holotype. 13. Protoconch and early stage of teleoconch of holotype. Locality 28. Bar scale 0.1 mm.



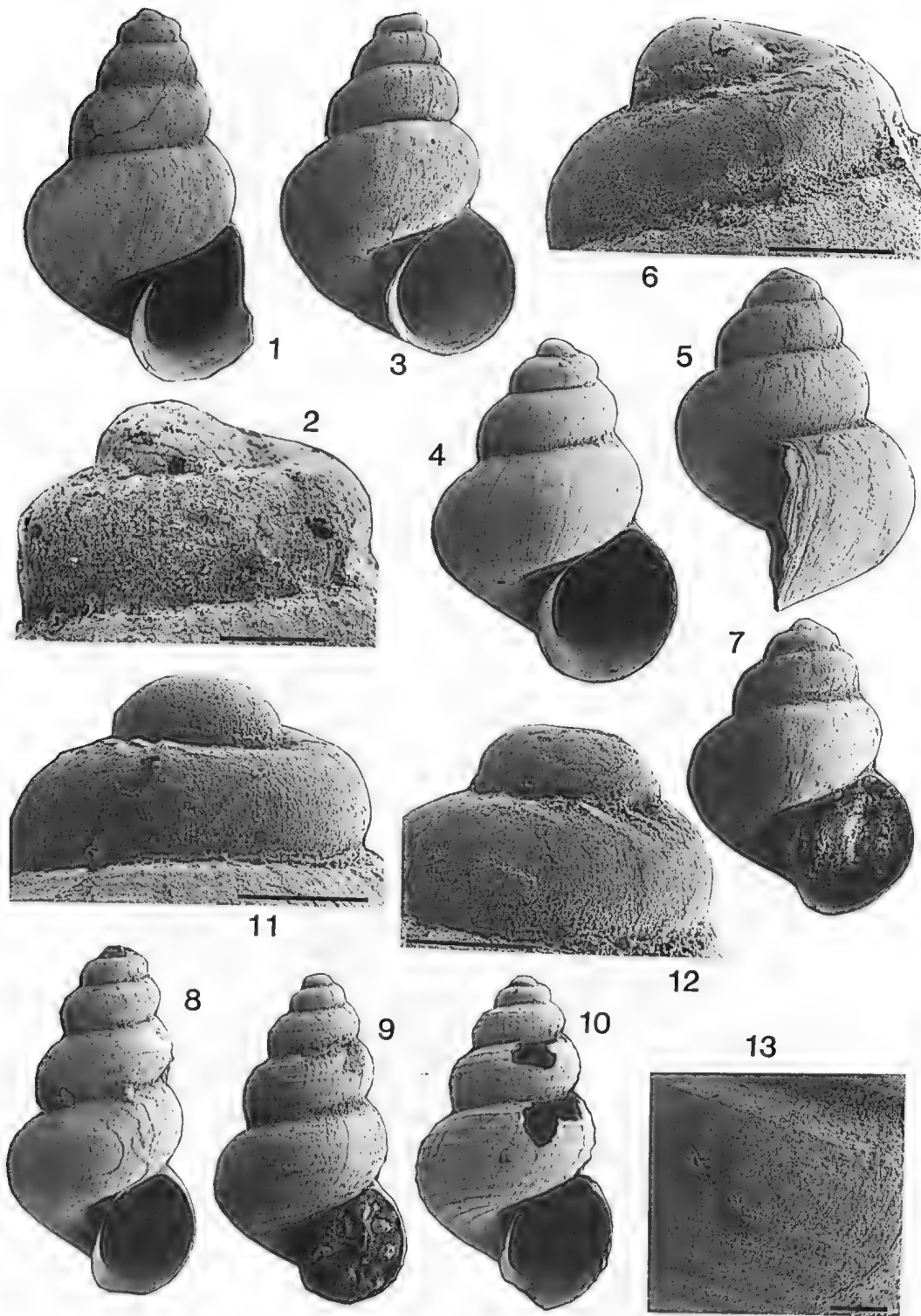


**Plate 18.** Figs 2-4. *Soleniscus callosus* Yoo. 2. Apertural view 7.2 mm x 4.3 mm (F78502a). 3. Apertural view 7.3 mm x 4.4 mm (F78502b). 4. Apertural view 7.7 mm x 4.6 mm (F78502c). Locality 25. Figs 1, 5-7. *Soleniscus* sp. 1. Apertural view, broken 3.8 mm x 2.6 mm (F78505). 5. Apertural view 6.5 mm x 4.4 mm (F78504). 6. Protoconch of Fig. 5. 7. Cluster of nodules on parietal inductura. Locality 25. Figs 8-12. *Strobeus ovalis* n.sp. 8. Paratype, apertural view 1.7 mm x 1.4 mm (F78498). 9. Figured specimen, apertural view 1.9 mm x 1.4 mm (F78500b). 10. Figured specimen, apertural view 3.0 mm x 2.1 mm (F78500a). 11. Figured specimen, apertural view 2.6 mm x 1.9 mm (F78500c). 12. Holotype, apertural view 1.9 mm x 1.4 mm (F78501). Localities 28 (holotype and paratypes) and 30 (figured specimens).

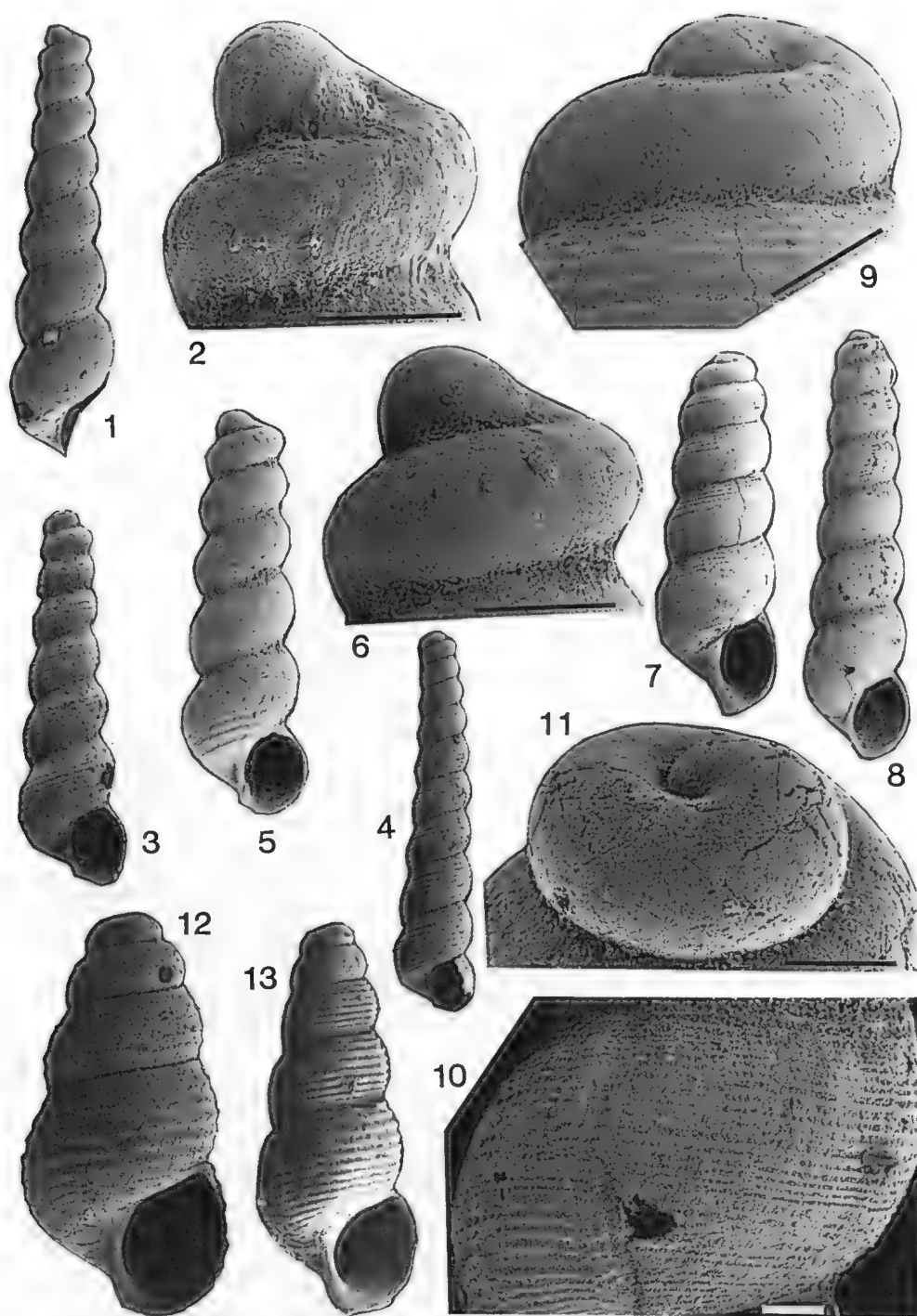




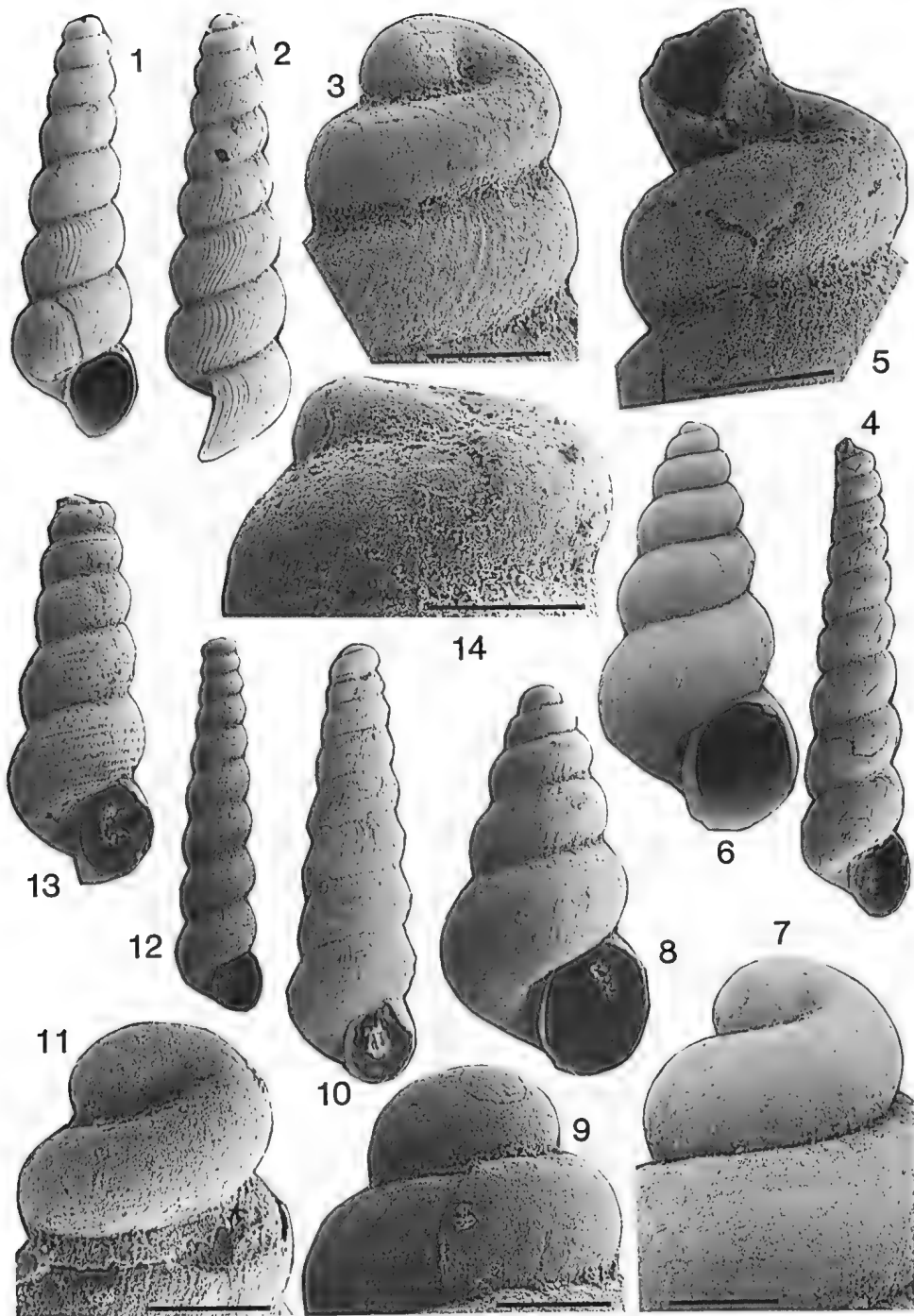
**Plate 19.** Figs 1-4. *Kimina australis* n.sp. 1. Paratype, apertural view 1.4 mm x 0.8 mm (F78511). 2. Paratype, apertural view 1.3 mm x 0.9 mm (F78512). 3. Holotype, apertural view 1.3 mm x 0.8 mm (F78513). 4. Oblique apical view of protoconch. Locality 24. Figs 5-8. *Cyclozyga* sp. 5. Apertural view 1.3 mm x 0.6 mm (F78503). 6. Protoconch of above specimen. 7. Apertural view 1.4 mm x 0.6 mm (F78506). 8. Protoconch of above specimen. Locality 24. Figs 9-11. *Girtyspira inflata* n.sp. 9. Holotype, apertural view 2.2 mm x 1.3 mm (F78515). 10. Paratype, apertural view, protoconch broken 2.6 mm x 1.4 mm (F78516). 11. Protoconch of holotype. Locality 23. Bar scale 0.1 mm.



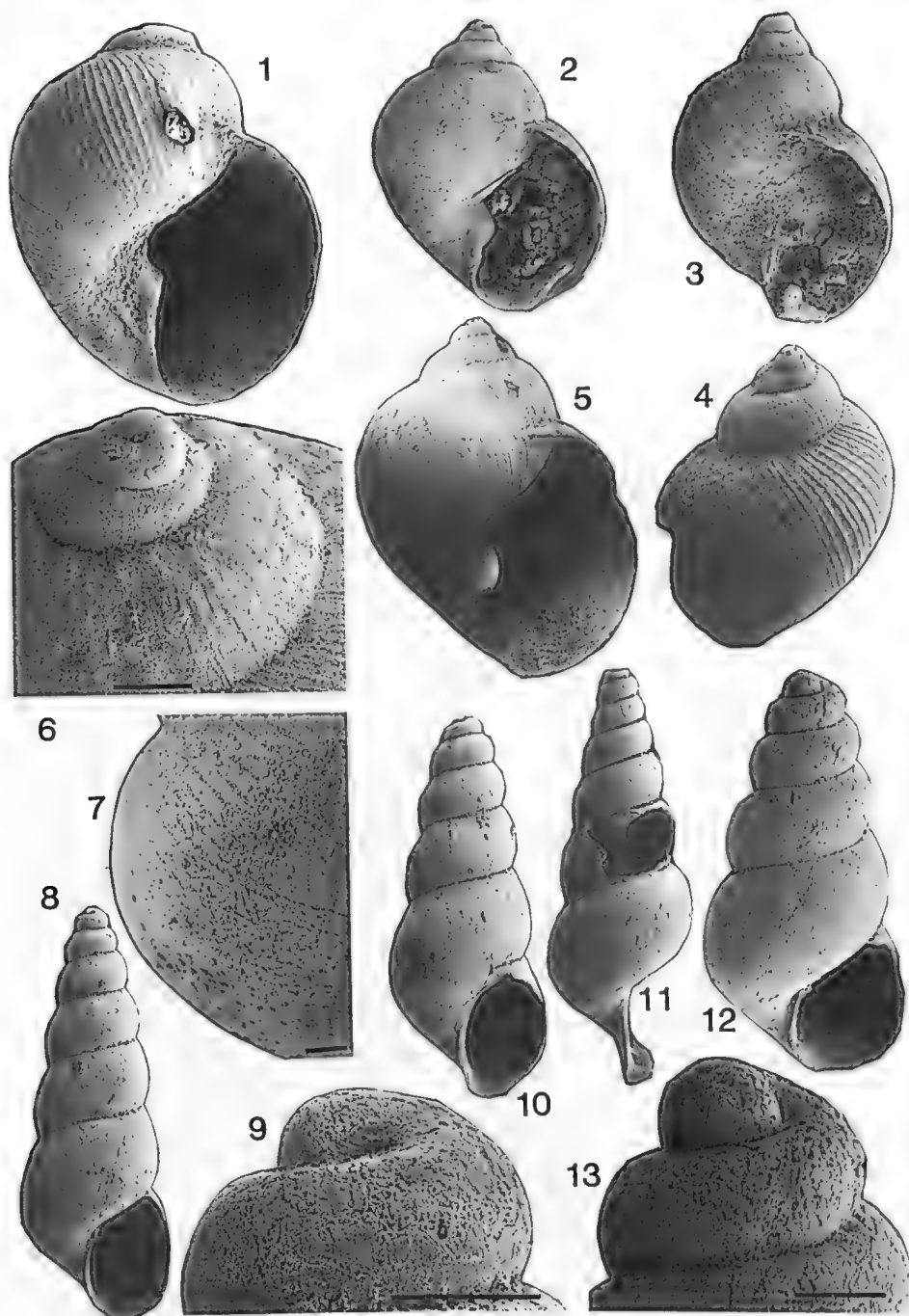
**Plate 20.** Figs 1-7. *Kimina globosa* n.sp. 1. Holotype, apertural view 2.2 mm x 1.4 mm (F78508). 2. Protoconch of holotype. 3. Paratype, apertural view 1.4 mm x 1.0 mm (F78509a). 4. Paratype, apertural view 1.0 mm x 0.9 mm (F78509c). 5. Paratype, side view 1.2 mm x 0.8 mm (F78509b). 6. Protoconch of Fig. 5. 7. Paratype, apertural view 1.1 mm x 0.8 mm (F78509d). Locality 28. Figs 8-13. *Palaeoalvania talenti* n.gen., n.sp. 8. Paratype, apertural view 1.9 mm x 1.0 mm (F78455a). 9. Paratype, apertural view 1.6 mm x 0.9 mm (F78455b). 10. Holotype, apertural view 1.6 mm x 1.1 mm (F78454). 11. Protoconch of holotype. 12. Protoconch of Fig. 9. 13. Teleoconch ornamentation of Fig. 9. Locality 28. Bar scale 0.1 mm.



**Plate 21.** Figs 1-6. *Donaldina minutissima* n.sp. 1. Paratype, apertural view 1.7 mm x 0.4 mm (F78510a). 2. Protoconch of Fig. 1. 3. Holotype, apertural view 1.7 mm x 0.6 mm (F78517). 4. Paratype, apertural view 2.6 mm x 0.6 mm (F78518). 5. Paratype, apertural view 1.1 mm x 0.4 mm (F78510b). 6. Protoconch of Fig. 3. Locality 28. Figs 7-10. *Pseudoaclisina microspirulata* n.gen, n.sp. 7. Paratype, apertural view 1.8 mm x 0.6 mm (F78520). 8. Holotype, apertural view 2.7 mm x 0.7 mm (F78519). 9. Protoconch of Fig. 5. 10. Ornamentation of final whorl of holotype. Locality 28. Figs 11-13. *Pseudoaclisina turgida* (Yoo). 11. Protoconch of Fig. 12. 12. Figured specimen 1.6 mm x 0.8 mm (F78461a). 13. Figured specimen 2.3 mm x 1.0 mm (F78461b). Locality 28. Bar scale 0.1 mm.



**Plate 22.** Figs 1-3. *Streptacis elegantissima* (Yoo). 1. Apertural view 1.6 mm x 0.5 mm (F78523). 2. Side view 1.9 mm x 0.5 mm (F78524). 3. Protoconch and early stage of teleoconch of Fig. 2. Locality 28. Figs 4-5. *Streptacis* sp. 4. Apertural view 2.0 mm x 0.5 mm (F78525). 5. Heterostrophic protoconch of Fig. 4, initial portion broken. Locality 24. Figs 6-9. *Kimina* sp. 6. Apertural view 1.9 mm x 0.9 mm (F78526a). 7. Protoconch and early stage of teleoconch of Fig. 6. 8. Apertural view 1.5 mm x 0.8 mm (F78526b). 9. Protoconch of Fig. 8. Locality 28. Figs 10-11. *Donaldina* sp. 10. Apertural view 1.7 mm x 0.5 mm (F78527). 11. Protoconch of Fig. 8. Locality 24. Figs 12-14. *Donaldina filosa* Yoo. 12. Apertural view 2.2 mm x 0.5 mm (F78521a). 13. Apertural view 1.4 mm x 0.5 mm (F78521b). 14. Protoconch of Fig. 13. Locality 28. Bar scale 0.1 mm.



**Plate 23.** Figs 1-7. *Globobulimorpha costata* n.gen., n.sp. 1. Paratype, apertural view 2.0 mm x 1.6 mm (F78496b). 2. Holotype, apertural view 1.9 mm x 1.5 mm (F78495). 3. Paratype, apertural view 1.7 mm x 1.3 mm (F78496a). 4. Paratype, dorsal view (F78497b). 5. Paratype, apertural view 1.5 mm x 1.1 mm (F78497a). 6. Protoconch and early stage of teleoconch of Fig. 1. 7. Teleoconch ornamentation of Fig. 1. Locality 28. Figs 8-13. *Streptaxis gundyensis* n.sp. 8. Holotype, apertural view 2.5 mm x 0.9 mm (F78522). 9. Protoconch of holotype. 10. Paratype 2.1 mm x 0.8 mm (F78528a). 11. Paratype 2.7 mm x 1.0 mm (F78528b). 12. Paratype 1.4 mm x 0.7 mm (F78531). 13. Protoconch of Fig. 12. Locality 28. Bar scale 0.1 mm.



## Studies on the Zoarcidae (Teleostei: Perciformes) of the Southern Hemisphere. VII. A New Species of *Dieidolycus* Anderson, 1988 from the Bismarck Sea

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**ABSTRACT.** A new species of abyssal eelpout is described from two specimens trawled north-west of Rabaul, New Britain. It is the second species of the genus *Dieidolycus*, previously thought to be endemic to the antarctic. The new species is distinguished from its congener by its fewer pectoral-fin rays and more posterior dorsal-fin origin.

ANDERSON, M.E., 1994. Studies on the Zoarcidae (Teleostei: Perciformes) of the southern hemisphere. VII. A new species of *Dieidolycus* Anderson, 1988 from the Bismarck Sea. Records of the Australian Museum 46(2): 121–124.

In September and October 1991 several deep-water trawls were made from the Australian national research vessel *Franklin* in the Bismarck Sea. In one haul north-west of Rabaul, New Britain, two small eelpouts (Zoarcidae) were taken by zoologists of the Australian Museum, Sydney. The specimens were sent to the author for study in April 1992 and although they had suffered some net damage, they were found to be diagnosable as a new species of the genus *Dieidolycus*, recently described from the antarctic abyss (Anderson, 1988).

length (SL) and head length (HL) are used in morphometric proportions. Types are deposited at the Australian Museum, Sydney (AMS). Other institutional abbreviations follow Leviton *et al.* (1985). Counts of fin rays, vertebrae, and other osteological observations were taken from radiographs. Drawings were made with the aid of photographs and a camera lucida.

### *Dieidolycus adocetus* n.sp.

Figs 1, 2

### Materials and Methods

Measurements were made with dial callipers to the nearest 0.1 mm. Definitions of characters, their measurement and quantification follow those of Anderson (1988), the first part of this series. Standard

**Type material.** HOLOTYPE, AMS I.32236-001, 88 mm (immature female), RV *Franklin*, Bismarck Sea, 3°41.5'S 151°52.2'E, 1957 m, 24 Sept.-14 Oct. 1991. PARATYPE, AMS I.32236-002, 73(+) mm (immature male), captured with holotype.



**Diagnosis.** A species of *Dieidolycus* as defined by Anderson (1988) with P 13; first dorsal-fin pterygiophore associated with vertebrae 5-6.

**Description.** The 2 specimens are damaged juveniles, with the skin torn away and, in the paratype, the tail tip missing and gill slits ripped. Head pore patterns cannot be determined. Counts and measurements are those of the holotype, paratype in parentheses.

Vertebrae 23 + 56 = 79 (23 + 40+); D 72; A 55; C 8; P 13 (13); pelvics 2 (2); gill rakers 2 + 12 (2 + 10); pyloric caeca 2 (2); branchiostegal rays 6 (6); vomerine teeth 7 (4); palatine teeth 3-4 (3-4); pseudobranch absent. Following measurements in percent SL: predorsal length 26.1; preanal length 47.3; prepelvic length 16.7; body depth 8.0; pectoral length 12.6; pectoral base height 4.7; head length 22.5; head width 8.9, head depth 9.1; gill slit length 4.4. Following measurements in percent HL: head width 39.4 (37.6); head depth 40.4 (37.6); pectoral length 56.1 (60.2); pelvic length 19.2 (17.7); upper jaw length 37.9 (34.5); snout length 15.7 (13.8); eye diameter 11.1 (10.5); orbit diameter 27.8 (27.6); gill slit length 19.7; interorbital width 7.6 (8.3); interpupillary width 19.2 (20.4).

Head triangular, dorsal profile gently inclined anteriorly; nape flattened. Head large and robust, snout short and broad. Eye small, rounded, orbit large, ovoid. Six suborbital bones in L-shaped pattern around eye (Fig. 2). Single pair of short nostrils at snout tip, not reaching upper jaw. Pectoral fin origin just below body midline, insertion on abdomen. Gill slit extending ventrally to midpectoral height, slit vertical above that, no siphonal fold evident. Body short, ovoid in cross section.

Mouth moderately large, terminal. Upper jaw extending posteriorly to vertical through middle of eye. Teeth in palate sharp, conical. Vomerine teeth in small patch in holotype. Palatine teeth in single series, full complement not present in these juveniles. Outer teeth of both jaws larger than teeth of palate, in single series except just at symphysis where 3-6 teeth form second row (holotype).

Unpaired fins low, caudal fin of holotype worn (net damage), with 1 epural, 4 upper hypural and 3 lower hypural rays. First dorsal-fin pterygiophore associated with vertebra 5 (holotype) or 6 (paratype); last dorsal ray associated with third preural vertebra. No free dorsal-fin pterygiophores. First and second anal-fin

pterygiophores set anterior to haemal spine of first caudal vertebra; last anal ray associated with second preural vertebra (holotype). Pectoral fin large, wedge-shaped (middle rays longest), lowermost rays not appreciably thickened in these juveniles. Pelvic fins relatively long for a rudimentary feature, greater than eye diameter, of 2 rays each; no spine rudiment. All fin elements segmented soft rays except first flexible spine of dorsal.

Gill rakers on upper limb (epibranchial) small, blunt; upper rakers on lower limb (ceratobranchial) with tips squared off, lower rakers pointed, triangular. Branchiostegal rays 6, 4 articulating with ceratohyal and 2 with epihyal. Oral valve weak, not reaching anterior edge of vomer and nearly completely coalesced anterolaterally. Pseudobranch absent. Pyloric caeca 2 small, vestigial nubs.

Accurate colour description not possible because of the damage to these specimens. Still, small patches of black skin adhere to the head, throat, abdomen and unpaired fins (more extensive in paratype) that indicates the species is probably uniformly dark in life, like its congener. Lining of orobranchial chamber black.

**Comparisons.** Because of the damage to the new specimens, the thought that they might represent a new species of the monotypic *Taranetzella* Andriashev, 1952 was at first considered. *Taranetzella* differs from *Dieidolycus* in possessing scales, nine preoperculomandibular pores, and low papillae between the mandibular and suborbital pores. None of these characters could be verified in the new specimens. However, they also differ from *Taranetzella* in their significantly different vertebral counts (19-20 + 70-78 in *Taranetzella*), six suborbital bones (8 in *Taranetzella*), two pelvic rays (3 in *Taranetzella*) and lack of a pseudobranch. Other important characters the new species shares with its congener, *D. leptodermatus* Anderson, 1988, are a greatly reduced oral valve, small eyes and restricted gill slit (the latter also the condition in *Taranetzella*).

**Etymology.** From the Greek *adoketos* (unexpected, surprising) alluding to the species' capture in the central Indo-west Pacific region.

**Remarks.** The finding of specimens of Zoarcidae under tropical seas is of great interest since these

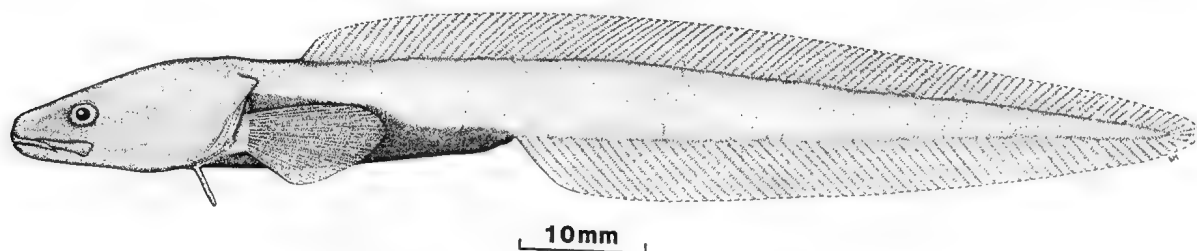


Fig. 1. *Dieidolycus adocetus* n.sp., holotype, AMS I.32236-001, Bismarck Sea.



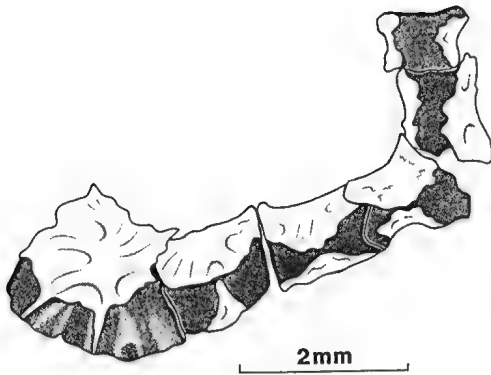


Fig. 2. *Dieidolycus adocetus* n.sp., left suborbital bones of paratype, AMS I.32236-002.

fishes are primarily found in the cold waters of high latitudes (Anderson, 1984). However "tropical" an influence the waters of lower latitudes has on the distribution of shore fishes, temperatures at the great depths that tropical zoarcids encounter are within the realm of temperatures found in other areas they inhabit. Thus, tropical slope areas are not well demarcated zoogeographic barriers to this family, and many species are now known to range through both temperate and tropical regions (4 species each of *Lycodapus* Gilbert, 1890 and *Melanostigma* Günther, 1881 and three species of *Pachycara* Zugmayer, 1911 [Anderson, 1989a, 1989b, 1990]). Vaillant (1888) reported the first zoarcids (*Pachycara crassiceps* [Roule, 1916]; see Anderson, 1989a) from tropical slope waters from the 1883 eastern Atlantic cruise of the *Talisman*, recording a temperature of 4.5°C at their maximum capture depth of 1493 m. Garman (1899) reported the second occurrence of zoarcids from tropical seas, these from the 1891 *Albatross* cruise in the eastern Pacific. Twelve nominal species were found between 838 and 3281 m at temperatures between 5.5 and 2.1°C, respectively.

The Indo-west and South Pacific are newly discovered distributional areas for the Zoarcidae. Andriashev & Fedorov (1986) reported the first two species in the region from specimens trawled from the New Zealand Plateau. Anderson (1989a) described the first benthic Indo-west Pacific zoarcid, *Pachycara shcherbachevi*, from 2600 m in the Bay of Bengal. Anderson (1990) reported on additional specimens from the south-western Pacific, three species of which (genus *Melanostigma*) are mesopelagic. *Dieidolycus leptodermatus* from the Antarctic, one specimen of which was taken directly south of New Zealand, was not discussed by Anderson (1990), as it was thought to be an Antarctic abyssal endemic.

Although the ichthyofauna of the basins of the tropical western Pacific is poorly known, future trawling may reveal a presently unknown zoarcid fauna, although it may not be very diverse. This seems the most likely hypothesis for this area, since the relationships of the currently known forms (*Dieidolycus*, *Melanostigma*

and *Pachycara*) are with widespread congeners of the southern hemisphere and not with lineages of the adjacent cold-temperate north-western Pacific. This latter area is dominated by different genera of Lycodinae (*Bothrocara*, *Lycenchelys*, *Lycodes*, etc) and Gymnelinae that are limited in their southerly distribution to the temperate waters of the Japanese archipelago (Anderson, 1984). Still, as yet unknown species of the broadly distributed *Lycenchelys* may be found in abyssal waters of the western tropical Pacific in future.

**Comparative material.** *Taranetzella lyoderma* Andriashev, 1952: CAS 53876, sex unknown, 98 mm SL, 45°09.3'N 125°38.3'W, 2669 m, off Oregon, USA; OSUO 2072, immature female, 158 mm SL, 44°34.8'N 125°33.6'W, 2816 m, off Oregon.

*Dieidolycus leptodermatus* Anderson, 1988: see Anderson, 1988: 72.

**ACKNOWLEDGMENTS.** I thank Daniel M. Cohen, Los Angeles County Museum of Natural History, for alerting me to the collection of this new eelpout, Mark McGrouther and John R. Paxton of the Australian Museum for information and curatorial help, Elaine Heemstra of the J.L.B. Smith Institute of Ichthyology for her fine drawing of a difficult specimen, and Robin Stobbs, also Smith Institute, for technical assistance.

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## Generic Positions of Australian Psocoptera Currently Placed in *Paracaecilius* Badonnel and *Enderleinella* Badonnel (Insecta: Psocoptera: Caeciliidae)

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**ABSTRACT.** *Paracaecilius lemuris* n.sp. is described from New South Wales and the generic position of *P. globiclypeus* (Enderlein) n.comb., *P. hilli* (Smithers) n.comb., *P. zelandicus* (Tillyard) n.comb. and *Enderleinella hylobius* (Smithers) n.comb. discussed.

SMITHERS, C.N., 1994. Generic positions of Australian Psocoptera currently placed in *Paracaecilius* Badonnel and *Enderleinella* Badonnel (Insecta: Psocoptera: Caeciliidae). Records of the Australian Museum 46(2): 125–129.

The psocopteran family Caeciliidae is worldwide in distribution, with over 200 described species in about 16 genera. There are at present 16 recognisable Australian species placed in seven genera. This paper deals with the Australian species of *Paracaecilius* Badonnel and *Enderleinella* Badonnel. Large populations of species in these genera sometimes occur and they are important elements of arboreal ecosystems. They are found on the foliage of broad leaved plants, especially of rainforest trees, and are mainly yellowish, creamy or white with little in the way of conspicuous or characteristic patterns. As a group they are very similar to one another in general morphology. Some of the taxonomically useful features, such as female genitalia, are very lightly sclerotised, requiring careful dissection and staining if they are to be used reliably for identification. With the current increase in surveys being undertaken in Australian rainforests it is important that taxonomic studies and determination of the generic position of these frequently encountered species be carried out.

Mockford (1965b, 1966, 1969, 1989) has made an important study of the genera of the Caeciliidae, based mainly on American species, which has resulted in recognition of several species groups in the large genus *Caecilius* Curtis. The study is still incomplete and authors have continued to describe species from many parts of the world, including Australia, in *Caecilius*. It is clear that most, if not all, of the Australian species will eventually have to be moved to other genera. When Mockford established the genus *Xanthocaecilius* (Mockford, 1989: 268) for a western hemisphere group he provided information on characters which distinguish it from *Paracaecilius* and *Enderleinella* and hence, incidentally, also gave features which redefined and distinguished these two genera from each other. This provides an opportunity to allocate species to these two very similar genera with greater confidence than was possible before. Broadhead & Richards (1982), when dealing with African species, also provided additional information on morphological details of *Paracaecilius*. Mockford (1989:292) defined subfamilies and tribes

within the Caeciliidae. In his scheme *Paracaecilius* and *Enderleinella* are placed in his Paracaeciliinae on the basis of possession of the following combination of features: ocelli present; abdomen with three ventral vesicles; male aedeagus blunt-tipped and endophallus 2-lobed or not divided; female gonapophyses short and broad, with one or two setae on the remnant of the external valve. He placed them in the tribe Paracaeciliini (as opposed to the Aphyopocini, the only other tribe of the Paracaeciliinae) on the following features: labral stylets absent; seven posterodistal labral sensilla present; wings not exceptionally long and narrow; cell R5 of the forewing not constricted in the middle; spermathecal sac separated from the sheath by a broad neck or narrowly separated from sheath by a short neck abutting on sheath or sheath absent; epiproct not elongated. Within this tribe *Paracaecilius* can be distinguished from *Enderleinella* by its having a very long, shallow, almost parallel-sided pterostigma with hardly any suggestion of a broadening in the distal third; the stem of Rs is almost straight basad of the separation of R2+3 and R4+5; the lacinia ends in two small cusps without either being particularly extended into a point; ventral and dorsal valves of the female gonapophyses with rounded apex; spermatheca with at most a short neck; phallosome transverse anteriorly, sclerotised frame thin and sometimes broken. In *Enderleinella*, although the pterostigma is shallow, there is at least slight suggestion of a broadening in the distal third; the stem of Rs is very slightly sinuous basad of the radial fork; there is at least one pointed extension at the distal end of the lacinia; the ventral valve of the female gonapophyses is pointed; the spermatheca has an obvious neck; anterior part of frame of phallosome strongly developed, not broken.

Three of the four species currently placed in *Enderleinella* have been recorded from Australia, namely *E. globiclypeus* (Enderlein), *E. zelandicus* (Tillyard) (both originally in *Caecilius*) and *E. hilli* Smithers. The fourth, *E. obsoleta* (Stephens), is a European species. A survey of the Psocoptera of Tuglo Wildlife Refuge, near Mount Royal, north of Singleton in the Hunter Valley, New South Wales, has revealed the presence there of *P. hylobius* Smithers and a new species of *Paracaecilius* (*P. lemuris* n.sp. described below). Study of this material has necessitated a reappraisal of the generic placing of all Australian species of *Enderleinella* and *Paracaecilius* taking into account Mockford's redefinitions.

Such a reappraisal reveals that *E. globiclypeus*, *E. zelandicus*, *E. hilli* and *P. lemuris* have the combination of features which place them in *Paracaecilius*. *Paracaecilius hylobius*, on the other hand, has those features which confirm that it should be placed in *Enderleinella*. Although Broadhead & Richards (1982) suggested this they did not formally move the species to *Enderleinella*.

It is possible that *P. globiclypeus* and *P. zelandicus* are the same species but it would be necessary to

examine the type of the former species before a definite decision could be made. It is likely, however, that the type was lost when the Psocoptera collections of the Hungarian Museum were destroyed.

As a result of this study the following generic placement is proposed for Australian species.

*Enderleinella hylobius* (Smithers) n.comb.

*Paracaecilius hylobius* Smithers, 1977: 261, figs 24-30.  
*Enderleinella hylobius*.—Broadhead & Richards, 1982: 161. (Placement in *Enderleinella* suggested but not formally established).

*Paracaecilius globiclypeus* (Enderlein) n.comb.

*Caecilius globiclypeus* Enderlein, 1903: 275.  
*Enderleinella globiclypeus*.—Smithers, 1977: 262.

*Paracaecilius hilli* (Smithers) n.comb.

*Enderleinella hilli* Smithers, 1979: 62, figs 10-12.

*Paracaecilius zelandicus* (Tillyard) n.comb.

*Caecilius zelandicus* Tillyard, 1923: 188, fig. 12, pl. 18 fig.7.  
*Enderleinella zelandicus*.—Smithers, 1969: 277, figs 41-43.

*Paracaecilius lemuris* n.sp.

Pl. 1 figs 1-9

**Type material.** HOLOTYPE, female, ALLOTYPE, male, PARATYPES, 4 females, 7 males, Tuglo Wildlife Refuge, 48 km, north of Singleton, NSW, 14 June 1992, A.S. Smithers. ADDITIONAL PARATYPES, all from type locality, 2 males, 3 females, 7-13 May 1974; 4 males, 10 May 1992; 2 males, 20 May 1992; 1 male, 30 May 1992; 4 males, 2 females, 14 Oct. 1978; 2 males, 10 Dec. 1978; 1 female, 17 Dec. 1978; 2 males, 1 female, 30 May 1992; 1 female, 12 Aug. 1978; 1 male, 1 female, 21 Oct. 1978 (A.S. Smithers); 6 males, 12 June 1988 (M.S. Moulds); 1 female, 17 July 1988; 1 male, 29 May 1989; 4 males, 11 July 1988; 1 male, 11 Sept. 1988; 2 males, 23 June 1989; 1 female, 20 Aug. 1988; 1 female, 26 June 1988; 2 males, 22 Oct. 1988; 1 male, 3 July 1988; 1 female, 14 Aug. 1988; 2 males, 1 female, 25 Sept. 1988; 1 male, 18 Aug. 1988; 1 male, 1 female, 2 Oct. 1988; 1 male, 3 Sept. 1988; 1 female, 12 June 1988; 9 males, 3 females, 18 Sept. 1988 (Malaise trap). Holotype, allotype and paratypes in the Australian Museum.

**Description.** FEMALE. *Colouration* (in alcohol). Head, body and legs pale creamy white with suggestion of a greyish area on either side of median epicranial suture and V-shaped mark of similar colour on frons; 2 narrow, pale brown, longitudinal bands on dorsum of thorax. Fore wings (Fig. 1) hyaline, almost colourless but with very pale brown anal cell. Hind wings hyaline. To the naked eye in life the insect appears almost white with conspicuous, dark eyes and a pair of longitudinal pale brown bands on the dorsum of the thorax.

**Morphology.** Length of body: 2.8 mm. Median epicranial suture distinct. Postclypeus strongly bulbous. Epicranium broadly rounded. Antennae shorter than wings. Length of flagellar segments: f1:0.73 mm; f2:0.62 mm. Eyes fairly large, level with vertex when viewed from side. IO/D (Badonnel): 1.0; PO:0.72; IO/D (Pearman):1.25. Ocelli small. Lacinia (Fig. 6). Measurements of hind leg: F:0.67 mm; T:1.3 mm; t1:0.38 mm; t2:0.11 mm; rt:3.5:1; ct:26.0. Each trochanter has what appears to be a group of placoid sensilla in the distal half. Fore wing length: 3.7 mm;

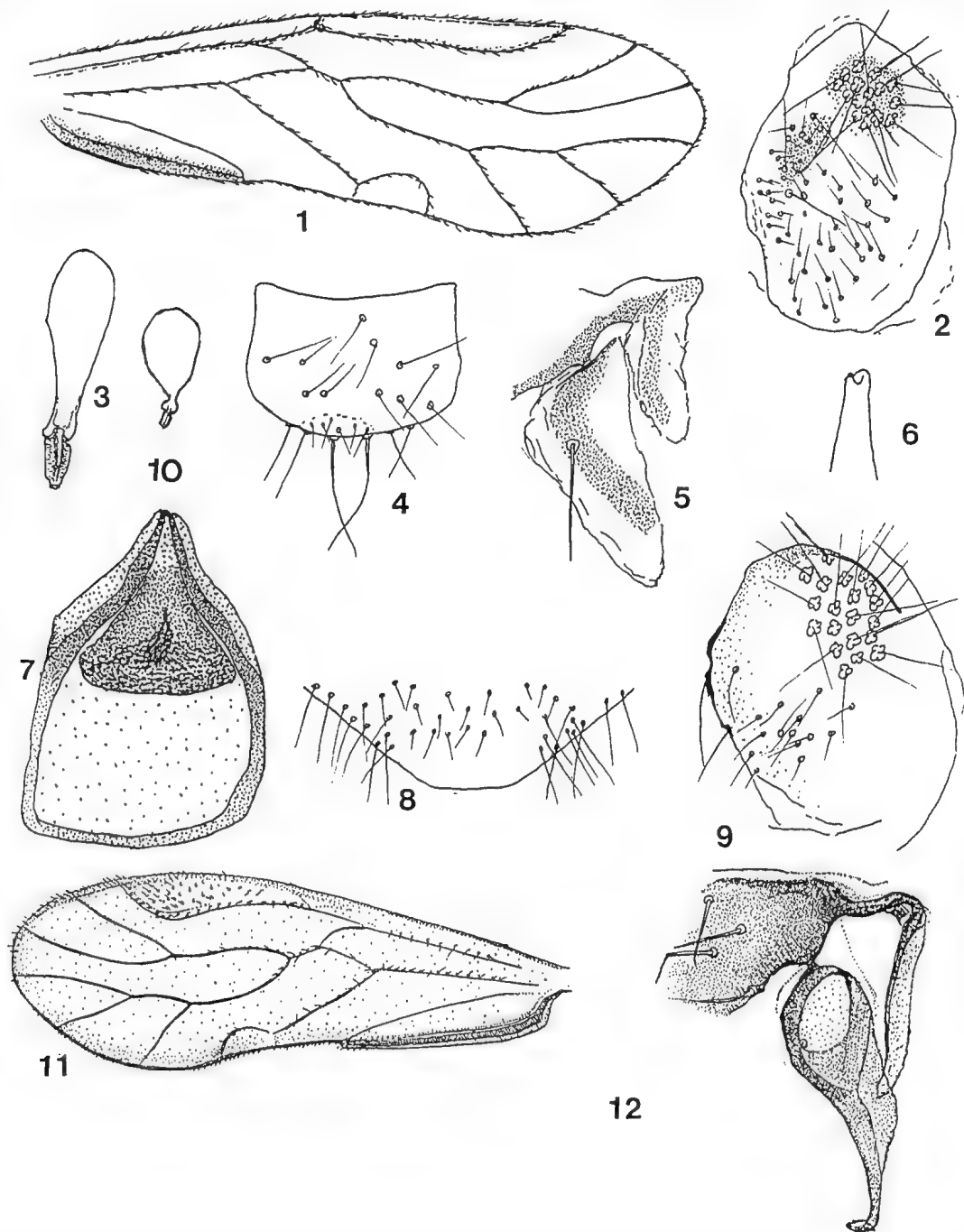


Plate 1. Figs 1-9 = *Paracaecilius lemuris* n.sp. 1 - female forewing; 2 - female paraproct; 3 - female spermatheca; 4 - female epiproct; 5 - female gonapophyses; 6 - female lacinia; 7 - male phallosome; 8 - male hypandrium; 9 - male paraproct. Figs 10-12 = *Enderleinella hylobius*. 10 - female spermatheca; 11 - female forewing; 12 - female gonapophyses.

width: 1.2 mm. Fore wings (Fig. 1) long and narrow, length:width = 3:1. Costa slightly broadened in pterostigma. Pterostigma long and narrow, with merest suggestion of widening at about distal three quarters. Rs and M fused for a length. Stem of Rs straight basad of radial fork beyond separation from M. R2+3 slightly sinuous, R4+5 running forward slightly to wing margin. Areola postica small. Veins sparsely setose, Cu2 glabrous. Hind wing long, narrow. Veins glabrous, margin setose from distal to R1 to anal area. Epiproct (Fig. 4) simple, rounded behind, setose, with 2 setae thicker than others near hind margin. Paraproct (Fig. 2). Subgenital plate rounded behind, evenly setose, without lateral styli. Spermatheca (Fig. 3) long, broadened anteriorly, with narrow neck and short glandular sheath, apparently no villiform projections in neck. Gonapophyses (Fig. 5) with ventral and dorsal valves rounded apically, membranous but with lightly sclerotised, longitudinal band, curved in case of dorsal valve. External valve represented only by a long seta arising from dorsal valve.

MALE. *Colouration* (in alcohol). As female but greyish area on top of head less obvious.

*Morphology*. Length of body: 2.2 mm. Median epicranial suture more distinct than in female. Vertex narrowed because of much greater eye size. Eyes very large, reaching well above vertex when viewed from side. IO/D (Badonnel): 0.31; PO: 0.84; IO/D (Pearman): 0.36. Ocelli larger than in female. Antennae much thicker than in female, almost as long as fore wing. Length of flagellar segments: f1: 0.70 mm; f2: 0.72 mm. Lacinia as in female. Measurements of hind leg: F: 0.65 mm; T: 1.19 mm; t1: 0.40 mm; t2: 0.11 mm; rt: 3.6:1; ct: 28.0. Sensilla on trochanter as in female. Fore wing length: 4.0 mm; width: 1.5 mm. Length:width = 2.6:1. Venation and setae as in female. Hind wing length: 2.9 mm; width: 1.0 mm. Epiproct simple, rounded behind, sparsely setose. Paraproct (Fig. 9). Hypandrium (Fig. 8) simple, setose, longer setae near hind margin grouped towards lateral area leaving middle area almost glabrous. Phallosome (Fig. 7).

### Key to Australian Species of *Enderleinella* and *Paracaecilius*

(The males of *P. hilli* and *P. globiclypeus* have not been described)

1. Lacinia with at least one side extended into pointed 'tooth'. Slight widening of pterostigma (Fig. 11). Rs stem slightly sinuous (Fig. 11). Ventral valve of gonapophyses pointed (Fig. 12) ..... *E. hylobius*
- Lacinia without a pointed extension at apex. Pterostigma elongated, almost parallel sided (Fig. 1). Rs stem almost straight (Fig. 1). Ventral valve of gonapophyses, broad, rounded (Fig. 5) (*Paracaecilius*) ..... 2
2. Very pale species, almost white when alive ..... 3
- Creamy yellow species ..... 4
3. Ventral valve of gonapophyses hardly longer than wide. Dorsal valve short, broad (male not described) ..... *P. hilli*
- Ventral valve elongated, parallel sided, with round end. Dorsal valve long, broad, tapering, round ended ..... *P. lemuris*
4. Ventral valve of gonapophyses long, parallel sided, broadly rounded at end. Dorsal valve long, broad, tapering, round ended (male not described) ..... *P. globiclypeus*\*
- Ventral valve long, parallel sided, rounded at end. Dorsal valve tapering to narrow end ..... *P. zelandicus*\*

\*(As discussed above in the introduction to this paper it is possible that *P. globiclypeus* and *P. zelandicus* are the same species and that the matter can only be resolved by examination of the type of *P. globiclypeus*).

ACKNOWLEDGMENTS. I would like to thank Professor E.L. Mockford for helpful discussion of his unpublished work on the Caeciliidae and for commenting on a draft of part of this paper, Professor I.W.B. Thornton and Evan Schmidt for comments on the draft, my wife for collecting most of the specimens in a survey of Tuglo Wildlife Refuge, and Heidi Marks and Graeme Smithers for taking care of the Malaise trap during my absence.

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## Larvae, Adults and Relationships of the Monotypic Perciform Fish Family Lactariidae

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**ABSTRACT.** The development of *Lactarius lactarius* larvae is described based on three relatively poorly preserved specimens, 6 to 23 mm SL. Aspects of adult external morphology and osteology relevant to assessing the relationships of this taxon are also described. Larvae are notable for their limited head spination, large swim bladder and unusual pigmentation. They otherwise resemble carangids. *Lactarius* possess numerous adult autapomorphies. Previous suggestions that *Lactarius* is a member of the Sciaenidae, Scombridae or Serranidae are rejected. The conventional placement of *Lactarius* near the carangoid fishes cannot be rejected. A number of larval and adult characters indicate that *Lactarius* and *Mene* are the second and first sister groups, respectively, of the carangoid fishes *sensu* Smith-Vaniz and Johnson. However, none of these characters are unequivocal, and the relationships of *Lactarius* remain uncertain pending availability of larvae of the carangoid *Nematistius* and more larvae of *Lactarius*.

LEIS, J.M., 1994. Larvae, adults and relationships of the monotypic perciform fish family Lactariidae. Records of the Australian Museum 46(2): 131–143.

The false trevally or milk trevally, *Lactarius lactarius* (Bloch & Schneider, 1801) is a pelagic, nearshore, marine fish (Fig. 1) that occurs over soft bottoms on the continental shelf from the Persian Gulf eastward to Taiwan and the Admiralty Islands, and south to Australia and Fiji (Springer, 1982). Kumaran's (1984) report of its occurrence along the east African coast and islands in the western Indian Ocean needs confirmation. The species is common and of commercial importance throughout much of its range (however, Day, 1878, considered the flesh 'insipid'), and is frequently taken in trawls and seines in shallow water.

The relationships of this species have been a matter of dispute since the original description. Bloch & Schneider (1801) described the species as a member of

*Scomber*; however, in that genus they also included many pelagic marine species today distributed among several families, including the Scombridae, Carangidae, and Pomatomidae. Cuvier (1829) placed the species in the carangid genus *Seriola*. Valenciennes (*in* Cuvier & Valenciennes, 1833) described the genus *Lactarius* with *Scomber lactarius* as the type species, and placed it in his "tribe Scomberoides" among such genera as *Lichia* and *Seriola* (now in the carangoid family Carangidae), *Pomatomus* (now in the scombroid family Pomatomidae), and *Nomeus*, *Naucrastes* and *Psenes* (now in the stromateoid family Nomeidae). Günther (1860) placed *Lactarius* in the Carangidae, but noted it "approaches Sciaenidae", and Day (1878) did not disagree. Seale (1910) agreed with Bloch & Schneider that *Lactarius* was

a scombrid, but did not state why, and Regan (1913) felt it had the general characteristics of the Serranidae. Jordan (1923) created the monotypic family Lactariidae within the Carangiformes, and this rather vague arrangement has since been followed by most authors (but see Deng & Zhan, 1986).

Thus, there has been a general consensus over the last 70 years that *Lactarius* is relatively closely related to the carangoid fishes. However, this has been based on nothing more than general similarity, and the literature contains little other than general descriptions of the external morphology of *Lactarius lactarius*. Similarly, until the work of Johnson (1984) and Smith-Vaniz (1984), the Carangoidei had not been rigorously defined, and the taxa included in it have varied with author. Here, I consider the Carangoidei to include the Nematistiidae, the 'echeneoids' (Coryphaenidae, Echeneidae, Rachycentridae) and the Carangidae (Smith-Vaniz, 1984).

The Lactariidae is one of the few Indo-Pacific shorefish families for which egg and larval development is completely undescribed (Leis & Trnski, 1989). Chacko (1944) briefly described the ovarian eggs of *L. lactarius*. Nair (1952) provided a life-size photograph and brief descriptive notes of some juvenile fish (greater than 21 mm total length) he identified as *L. lactarius*. Unfortunately, the fish are not identifiable from the photograph, and the fin-ray counts given by Nair do not match those of *L. lactarius*, so the identification is questionable.

Recently, I was able to identify three larvae from northern Australia and the Gulf of Thailand as *Lactarius lactarius*. This stimulated me to examine the relationships of the family. To this end, I also studied aspects of adult morphology and osteology. Ultimately, it was obvious, that my larval material was too limited for the task (it is unlikely more larvae will be available soon), and I was unable to convincingly place *Lactarius* amid the complex Percoidei. The purpose of this paper is to

present the information gathered during the course of this study with the aims of describing the larval development of this taxon, and of providing a basic description of adult morphology and osteology, both for the first time. These data provide some suggestions as to the relationships of *Lactarius*, and can serve as a basis for future study.

## Methods and Materials

The three *Lactarius* larvae available for this study were in relatively poor condition, limiting the amount of information that I could obtain. Adults were x-rayed, and some specimens cleared and stained for study of bone and cartilage (Dingerkus & Uhler, 1977; Potthoff, 1984). However, in a few specimens, cartilage staining was unsuccessful.

Terminology and measurements of larvae follow Leis & Trnski (1989) except orbit rather than eye diameter was measured. Size refers to standard length. References to pigment are to melanin. Illustrations were done with the aid of a camera lucida, and show the left side unless noted otherwise.

**Identification.** I established the three larvae were of the same species by general body shape, a large gas bladder, fin-ray counts, myomere number, head spination, and pigment pattern. The myomere counts (24) and complete fin-ray counts of D VIII + I, 22-23 and A III, 26-27 eliminate from consideration all of the taxa occurring in the area except some carangids and *Lactarius*. The three larvae have an opercular spine (Leis & Trnski, 1989) and lack a space between the last two spines of the anal fin, so carangids could be eliminated. Additionally, no carangid species has more soft rays in the anal fin than in the dorsal fin (Leis & Trnski, 1989), whereas *Lactarius* does. Further confirmation of the



Fig. 1. *Lactarius lactarius* adult (140 mm total length). Figure after Sainsbury *et al.* (1985: 157), reproduced with permission.

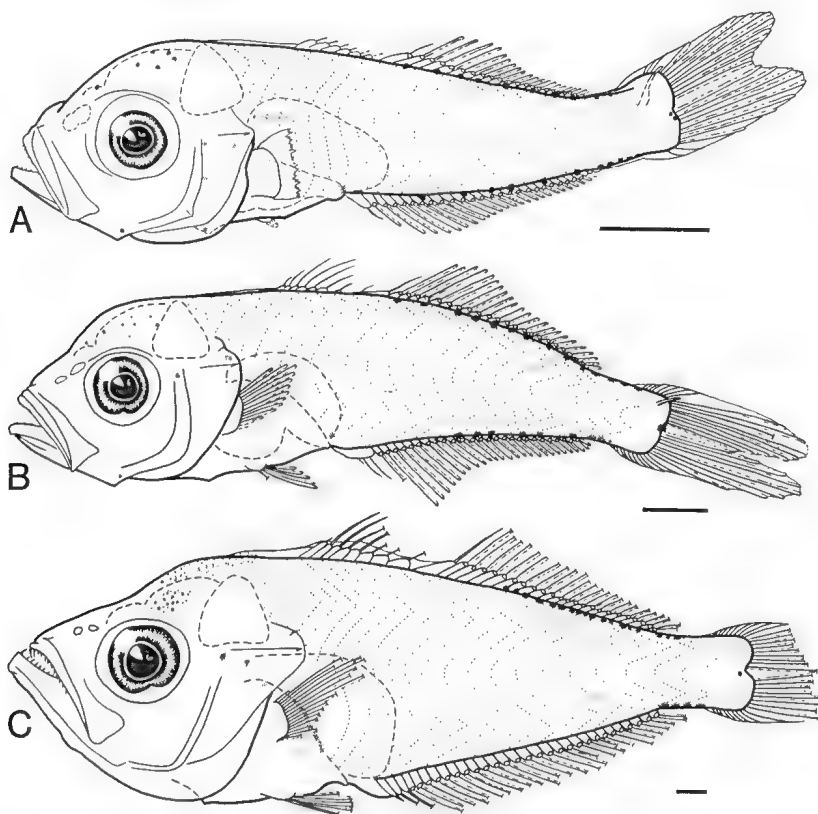
identification is the presence in the largest larva of enlarged, recurved, symphyseal canine teeth in both jaws – a characteristic of juvenile and adult *L. lactarius*.

**Material examined.** (Museum acronyms follow Leviton *et al.*, 1985, and are AMS unless noted otherwise; C&S indicates cleared and stained, X indicates x-rayed as well as examined specimen, L indicates larva) – Lactariidae, *Lactarius lactarius* – USNM 315570: 6.0 mm, L, Gulf of Thailand (Naga station S9-21, 60-959), plankton net; USNM 315571: 10.3 mm, L, Gulf of Thailand (Naga station S3-202, 60-105), stramin net; NTM S.10247-002: 23 mm, L, Shoal Bay, Northern Territory, Australia, capture method unknown; X, I.15557-121: 3, 110-145 mm; X, I.20826-010: 2, 180-200 mm; C&S I.21830-010: 133 mm; C&S I.31371-001: 2, 67-100 mm. Menidae, *Mene maculata* C&S I.15557-122: 70 mm; C&S unregistered, *L. Coryphaenidae*, *Coryphaena hippurus* C&S I.23606-001: 47 mm. Carangidae, *Caranx* sp. C&S I.28949-001: 60 mm; *Decapterus russelli* C&S I.32145-002: 95 mm; *Pseudocaranx dentex* C&S I.30872-002: 57 mm; *Scomberoides lysan* C&S I.24551-004: 42 mm; *Trachurus* sp. C&S I.30866-010: 52 mm. Sciaenidae, *Seriphus politus* X, I.564: 163 mm. In addition, a number of C&S perciform fishes were examined (AMS material): Apogonidae, *Fowleria variagata* I.26723-055,

*Cheilodipterus quinquelineatus* I.26723-056; Callanthiidae, *Callanthias australis* I.22871-004; Centrogenysidae, *Centrogenys vaigensis* I.24694-012; Girellidae, *Girella tricuspidata* unregistered; Kuhliidae, *Kuhlia rupestris* I.21262-002; Leiognathidae, *Leiognathus elongatus* I.20829-018; Lutjanidae, *Pristipomoides argyrogrammicus* I.25829-005; Nandidae, *Nandus pallidus* I.22130-003; Percichthyidae, *Nannoperca australis* unregistered; Pinguepididae, *Parapercis cylindrica* I.26723-059; Plesiopidae, *Belonepterygion fasciolatum* I.26723-058, *Plesiops coeruleolineatus* I.31487-004; Pomatomidae, *Pomatomus saltatrix* I.31372-001; Scorpidae, *Scorpius lineolatus* I.31238-006; Serranidae, *Pseudanthias squamipinnis* I.32478-002, *Epinephelus merra* I.20988-013, *Pseudogramma polyacantha* I.21540-048; Terapontidae, *Leiophtherapon unicolor* unregistered.

## Results

**Description of larvae.** Description is based on three larvae of 6.0, 10.3 and 23 mm, standard length (Fig. 2, Table 1). Therefore, many structures were fully developed in the smallest larva, and any characters present only in smaller larvae will have been missed.



**Fig. 2.** Larvae of *Lactarius lactarius*. Small, terminal hatch mark across axis of fin elements indicates broken spine or ray. Scale bars = 1 mm. A) 6.0 mm from the Gulf of Thailand (USNM 315570). Broken lines for posterior spines of the dorsal fin represent incompletely formed spines. B) 10.3 mm from the Gulf of Thailand (USNM 315571). Head drawn from right side due to damage on left side. C) 23 mm from near Darwin, Australia (NTM S.102447-002). Specimen in poor condition: most fin rays are broken, and no attempt has been made to show their true length.

Furthermore, two of the larvae are relatively faded, the 10.3 mm specimen has been damaged, particularly on the left side of the head, and the 23 mm specimen appears to have dried out at some stage. In spite of these limitations, a relatively complete description of the larvae can be provided.

The body is of moderate depth, laterally compressed, and slightly deeper at the pectoral base than at the anus. There are 9-10 + 14-15 = 24 myomeres. The gut is coiled, and the anus is located at 40-47% of standard length. A very large, conspicuous gas bladder is located above the gut, and extends a considerable distance posterior to the anus. With growth the head becomes increasingly pointed primarily due to increased protrusion of the lower jaw as the mouth becomes more oblique. The mouth is moderate to large, but does not reach the pupil in the two smaller larvae. Small, slightly recurved teeth are present in both jaws of the smallest larva. The 23 mm fish has enlarged, symphyseal canines in both jaws. Judging from the size of the orbit, the eye is large, but it appears to have shrunk in the available specimens. Gill membranes are free from the isthmus. No scales are evident on the two smaller larvae. The largest specimen appears to have incipient scales, or perhaps damaged scale pockets.

Head spination is confined to the preoperculum and operculum. Preopercular spination is limited to a small spine at the angle in the 6 mm specimen. There is no preopercular spination in the other two larvae. A weak opercular spine is present in all larvae, and a small second spine, dorsal to the first, is present in the two larger larvae.

The smallest larva is fully flexed, with a full complement of primary caudal rays. All but the posteriormost soft rays in the long-based dorsal and anal fins are present. The anterior rays of the fins are more than twice as long as the posterior rays. The spinous dorsal fin has six incompletely-formed spines. The first spine of the anal fin is present, but the next two elements, which ultimately become spines, appear

to be soft rays. Only incipient rays are present in the pectoral fins, and the pelvic fins are merely buds. In the 10.3 mm larva, the full complement of rays is present in all fins, except the pectoral fin where the lower rays are still incipient. The 23 mm larva appears to have all pectoral rays ossified. The fin spines are all slender and weak, none are particularly elongate, and none have any external ornamentation. There is no gap between the anus and the anterior margin of the first pterygiophore of the anal fin. The only unusual aspect of fin development is the apparent transformation of two anal rays into spines, but this needs to be confirmed when more specimens in better condition become available.

The head and trunk are lightly pigmented, whereas the tail is adorned with two prominent melanophore series. Scattered melanophores are present dorsally on the midbrain. These increase in number with growth and extended posteriorly. A single dorsal melanophore is present on each hemisphere at the juncture of mid- and hindbrains in the two smaller larvae. A single melanophore is present on the angle of the lower jaw in the two smaller larvae; the jaws are otherwise unpigmented. Only the smallest larva has a ventral melanophore just anterior to the cleithral symphysis. In all three larvae a melanophore is present at the base of the opercular spine in line with the centre of the eye. A few faint melanophores are present anteriorly on the gut and dorsally over the anterior portion of the gas bladder. Another melanophore is present on the dorsal surface of the gut at the anus. Along each side of the base of the soft rays of the dorsal fin is a series of melanophores. These are paired in the two larger larvae. The number of melanophores in this series increases with growth from about eight at 6 mm to 15 at 23 mm. A similar series of melanophores is present along the anal fin, but consists of six melanophores at 6 mm and 10.3 mm, and no melanophores at 23 mm. Each series extends onto the midline of the caudal peduncle where three to six unpaired melanophores are present. The

Table 1. Morphometric and meristic characters of larval *Lactarius lactarius*. Measurements in mm are defined in Leis & Trnski (1989) except as noted.

Character	Length of Larva		
	6.0 mm	10.3 mm	23.0 mm
Preanal Length	2.8	4.8	9.3
Predorsal Length	2.5	4.2	9.0
Head Length	2.1	3.4	8.3
Orbit Diameter	0.8	1.2	3.0
Snout Length	0.6	1.1	1.8
Body Depth at Pectoral	1.7	2.8	7.6
Body Depth at Anus	1.4	2.4	7.1
Caudal Peduncle Length	0.9	1.4	2.8
Maxilla Length	1.0	1.5	3.5
Dorsal Fin	VI+I,20	VIII+I,22	VIII+I,23
Anal Fin	I,25	III,26	III,27
Caudal Fin	3/9+8/2	9/9+8/9	9/9+8/9
Pectoral Fin	0	10	16
Pelvic Fin	0	I,5	I,5

only lateral pigment on trunk or tail consists of one or two melanophores midlaterally at the base of the central caudal rays.

**Comparison with other taxa.** Larvae of *Lactarius* are most likely to be confused with larvae of carangids and nomeids, as these are similar in general morphology and in pigment. Carangids can be distinguished because they have much more extensive spination on the head than does *Lactarius* (Leis & Trnski, 1989), although the latter has an opercular spine which carangids lack. Also, once the fins are formed, carangids have a gap between the last two spines of the anal fin. Nomeids such as *Cubiceps* have shape, pigment and head spination similar to that of *Lactarius*, but they have 30 or more myomeres (Ahlstrom *et al.*, 1976), while *Lactarius* has only 24. The, as yet, unknown preflexion larvae of *Lactarius* are likely to be confused with some apogonids because both have large swim bladders. However, apogonids have many fewer fin rays in dorsal and anal fins, and many have well-developed spination on the head (Leis & Rennis, 1983). It must be emphasised that preflexion larvae of *Lactarius* could have more extensive spination on the head than do the postflexion larvae. It should also be noted that the two smaller *Lactarius* larvae were captured at night (time of capture is unknown for the largest specimen), and the swim bladder in fish larvae typically is more inflated at night than it is during the day.

**Description of adults.** The general external morphology of *Lactarius lactarius* is well described and illustrated in the literature (Weber & de Beaufort, 1931; Kyushin *et al.*, 1982; Gloerfelt-Tarp & Kailola, 1984; Sainsbury *et al.*, 1985), and only a few particularly relevant features will be mentioned. Scales are large, cycloid, and deciduous, the lateral line is not armed with scutes, nor is the caudal peduncle particularly narrow, the dorsal and anal fins are long-based, and the second and third anal spines are not separated by a gap (Fig. 1). The following meristic values apply (Johnson, 1984; present study): D VII-VIII + I, 19-23; A III, 25-28; P<sub>1</sub> 17; C 9+8; vertebrae 10+14. Among percoid fishes, it is unusual for the anal fin to have more soft rays than the dorsal fin (Johnson, 1984). In only 14 of about 80 percoid families does this occur (none of them carangoid families), and in only six families or incertae sedis groups does the anal fin have four or more rays than the dorsal (Cepolidae, Lactariidae, Leptobramidae, *Neoscorpis*, Pempheridae, Toxotidae).

Günther (1860) briefly described the swim bladder and skull. Alam *et al.* (1989) described the penetration of the swim bladder by the anterior pterygiophores of the anal fin. Deng & Zhan (1986) described the lateralis system of *Lactarius* and compared it with those of some carangoid fishes and some others "assumed to be related with the Carangidae". They concluded the lateralis system of *Lactarius* was "very much different" from the Carangidae (as was that of *Coryphaena*), and maintained it was "better to classify them outside of the

carangoid fishes". However, Deng & Zhan (1986) nominated no taxon with a lateralis system similar to that of *Lactarius*, and made no comment as to which taxa either *Lactarius* or *Coryphaena* might be related.

**Soft anatomy.** Günther (1860) noted that *Lactarius* has an unusual swimbladder, and likened it to that of the Sciaenidae. Day (1878) and Weber & de Beaufort (1931) described it as bifurcate anteriorly and posteriorly, but it is not bifurcate posteriorly. The swim bladder has two anterior horns that communicate closely with the base of the skull (Fig. 3). It is otherwise carrot-shaped in dorsal view, lacks other appendages, and extends in adults nearly to the posterior end of the anal fin. Upon first examination, the tough, silvery tissue of the swim bladder appears to completely surround the first pterygiophore of the anal fin. But in fact, it passes to one side of the pterygiophore, enfolding it anteriorly and posteriorly, and reaches around the pterygiophore to meet, but not join, laterally. This maintains the overall carrot-shape. The next few pterygiophores are short and the remainder displaced laterally, so that the gas bladder is undivided and remains to one side of them. The gas bladder of *Lactarius* thus differs significantly from that of the Sciaenidae. In the Sciaenidae, including even *Seriphus*, which has a long anal-fin base, the bladder neither extends posterior to the anus nor enfolds the first anal pterygiophore.

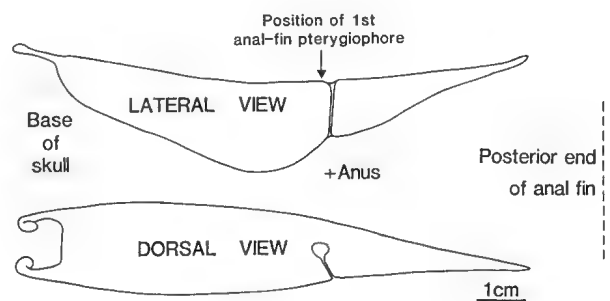


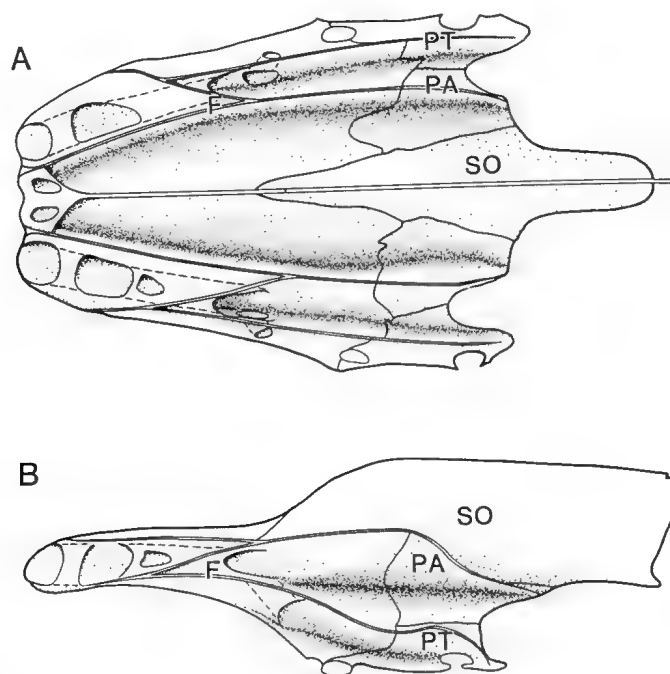
Fig. 3. Swim bladder of *Lactarius lactarius* (AMS I. 20826-010, 200 mm).

The arrangement of the ramus lateralis accessorius of the facial nerve is reported by Freihoffer (1963) to be his pattern 9. This is the most common pattern among percoid fishes.

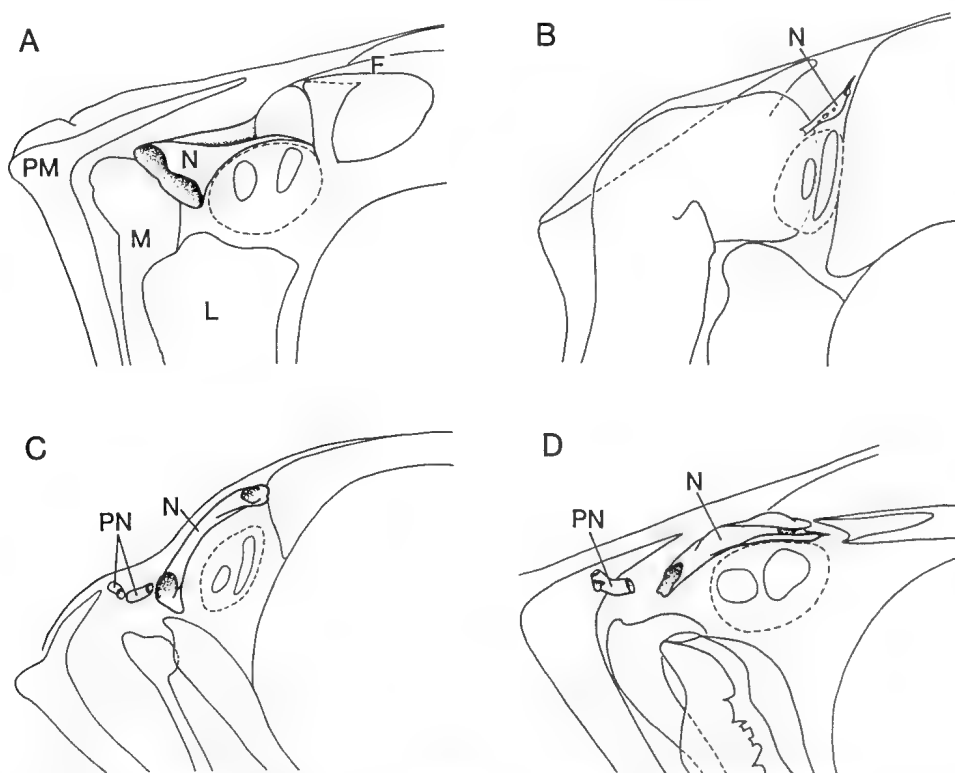
**Osteology.** The skull is cavernous as noted by Günther (1860), but in contrast to his conclusion, it is very different from that of sciaenids (Sasaki, 1989 and personal communication, December 1990). The most striking feature is a series of longitudinal, dorsal ridges separated by deep troughs (Fig. 4). A moderately high medial frontal-supraoccipital ridge runs to the anterior tip of the frontals (Fig. 4). A lower, frontal-parietal ridge runs approximately parallel to it, and parallel to this is a lower, shorter frontal-pterotic ridge. A short, oblique frontal ridge runs from mid-way along the

frontal-parietal ridge to the anterior end of the frontal-pterotic ridge. Anterior to the oblique ridge, the frontal trough is partially roofed over between the frontal-parietal and frontal-pterotic ridges. The deep trough formed between the frontal-supraoccipital and frontal-

parietal ridges is not roofed by bone anteriorly, although the posttemporal partially bridges it between the posterior end of the pterotic and the supraoccipital. No basoccipital foramen for insertion of the swimbladder 'horns' is present.



**Fig. 4.** Skull of *Lactarius lactarius* (based on two specimens, AMS I.31371-001, 67-100 mm) showing only frontals (F), supraoccipital (SO), parietals (PA) and pterotics (PT). A – dorsal view, B – lateral view.



**Fig. 5.** Nasal (N) and prenasal (PN) bones in *Lactarius*, *Mene* and two carangoid fishes. Also shown are frontals (F), premaxilla (PM), maxilla (M), and lachrymal (L). A – *Lactarius lactarius* (based on two specimens, AMS I.31371-001, 67-100 mm); B – *Mene maculata* (AMS I.15557-122, 70 mm); C – *Coryphaena hippurus* (AMS I.23606-001, 47 mm); D – *Scomberoides lysan* (AMS I.24551-001, 42 mm).



At the symphysis of both the dentaries and premaxillae is a cluster of two or three enlarged canine type 1 teeth (tooth type after Fink, 1981). These type 1 teeth are present in small and large individuals, and are not medial to the primary jaw teeth. The latter are apparently type 2 teeth. These canine teeth are widely spaced and arise from individual sockets, although only alternate ones are functional at any given time. Most of these primary teeth in the premaxillae disappear with growth, leading to a low, bony ridge. The dentary teeth in larger individuals coalesce to form a rugose ridge.

The nasal bone is not accompanied by any prenasal ossifications (Fig. 5A), and extends well anterior to the nasal capsule. It is trumpet-shaped and open along most of its dorsum.

The scapula has two foramina (Fig. 6A). The coracoid has a broad posterior lamina extending its entire length, with a second lamina extending along most of the anterior margin of the coracoid toward the cleithrum (Fig. 6A). The inter-osseous space is thus narrow to absent dorsally, but broad ventrally, and the coracoid and cleithrum do not touch ventrally but are connected by a strong ligament. The abductor muscles are large.

There are three 'T'-shaped supraneurals (Fig. 7), arranged /0+0/0+2/1+1 in my material, not 0/0/0+2/1+1 as noted by Johnson (1984). The first and second

neural spines are relatively broad and closely applied. The pterygiophores are slender. Epiplural ribs are located on centra one to eight, and pleural ribs are on centra three to ten.

The posterior pterygiophores of both the dorsal and anal fins are abruptly shortened. The last eight or nine dorsal-fin pterygiophores are about 25% shorter than the preceding ones. Similarly, the last four to six anal-fin pterygiophores are 15-20% shorter. In fishes with a very narrow caudal peduncle (eg, *Caranx*, *Mene*), the pterygiophores gradually become shorter posteriorly, but the distance from the proximal end of the pterygiophore to the vertebral centra changes little. In *Lactarius* this distance abruptly becomes greater in the shortened elements.

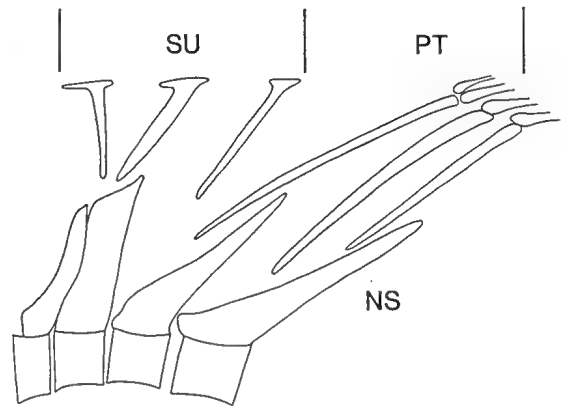


Fig. 7. Supraneurals (SU), anterior dorsal-fin pterygiophores (PT), and neural spines (NS) of adult *Lactarius lactarius* (based on cleared and stained and radiographed specimens). Radials of pterygiophores not distinguished.

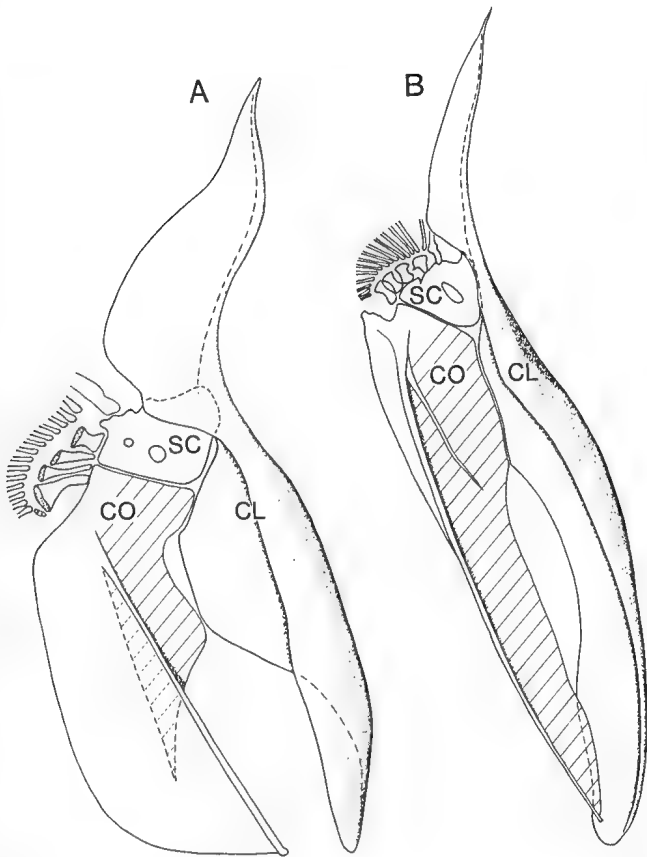


Fig. 6. Lateral view of right pectoral girdle of A) *Lactarius lactarius* (AMS I.31371-001, 100 mm), and B) *Mene maculata* (AMS I.15557-122, 70 mm). Cleithrum (CL), scapula (SC), coracoid (CO). The anterior lamella of the coracoid is hatched.

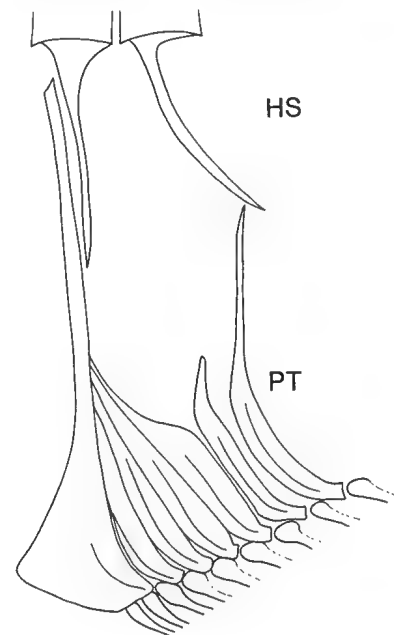


Fig. 8. Anterior anal-fin pterygiophores (PT) and haemal spines (HS) of *Lactarius lactarius* (based on cleared and stained and radiographed specimens). Radials of pterygiophores not distinguished.

The separation of the spiny and soft portions of the dorsal fin is accomplished by elongation of the seventh pterygiophore. There is no spineless pterygiophore in the gap between the two parts of the fin.

The first anal-fin pterygiophore is enlarged, and has an anterior, distal extension (Fig. 8). This is a common feature of deep-bodied, strongly compressed fishes (Zeiformes, Acanthuroidei, Carangidae, etc.). What is unusual in *Lactarius* (apparently unique) is the arrangement of the other anal pterygiophores. Pterygiophores two through five are strongly applied to one another, and, in turn to the posterior edge of the

enlarged first. This mass of bones was called the 'anchor bone' by Alam *et al.* (1989). Pterygiophore six is reduced and apparently free proximally. The remaining anal pterygiophores are of 'normal' size and associated with the haemal spines, but are displaced laterally to make room for the posterior extension of the swim bladder.

The branchial arch of *Lactarius* (Fig. 9) has all the elements of the primitive percoid branchial skeleton (Johnson, 1980): one basihyal, four basibranchials (the fourth cartilaginous), three hypobranchials, five ceratobranchials, four epibranchials, four pharyngobranchials (the fourth a

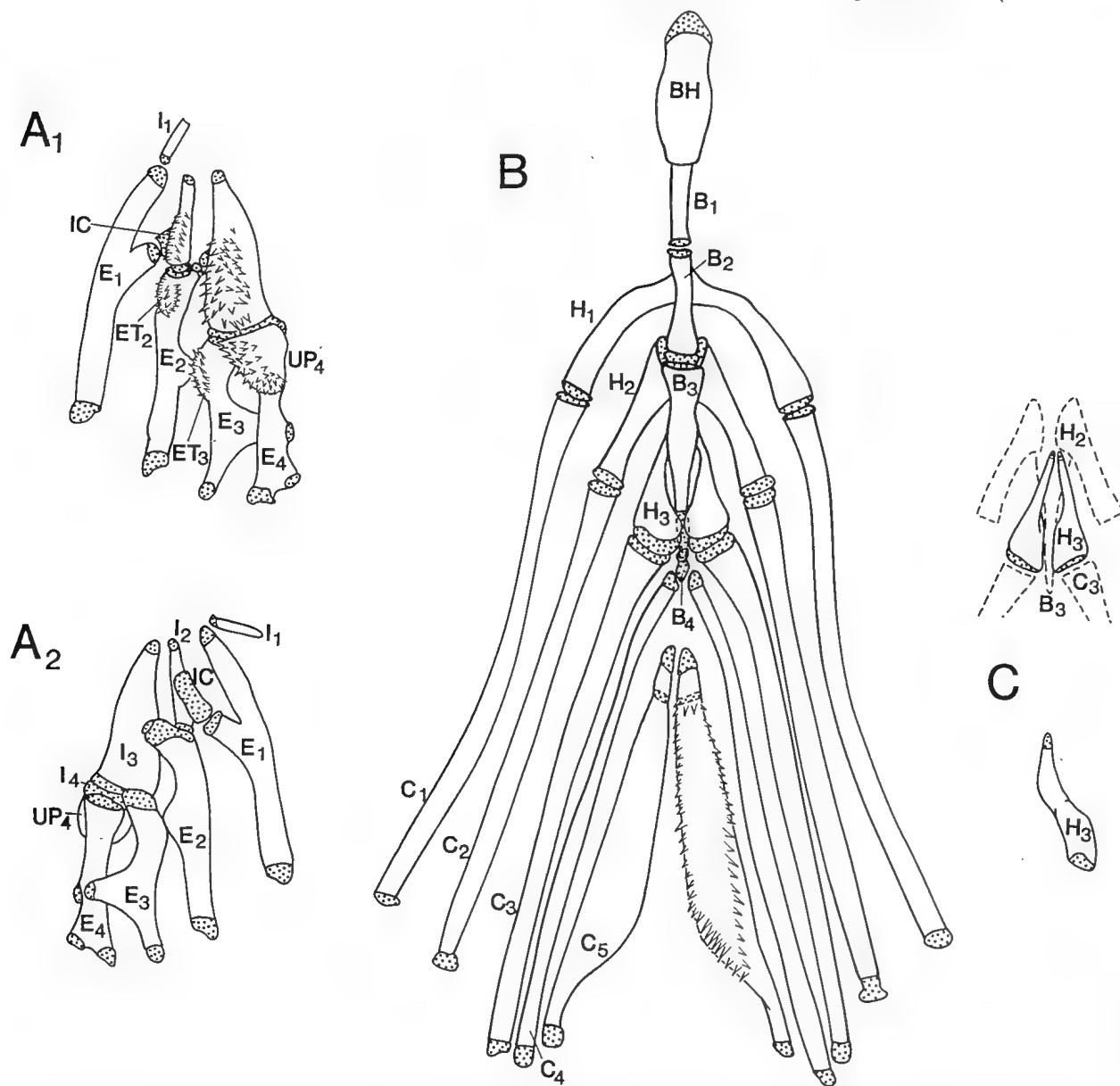


Fig. 9. Branchial arches of *Lactarius lactarius* (AMS I.31371-001): anterior is to the top of the page in all illustrations which are all to the same scale. Shaded areas are cartilage, and gill rakers are omitted. A) Upper right arches: A1 is a ventral view, and A2 a dorsal view. B) Lower arches in dorsal view. Peripheral teeth only are shown on right C5 toothplate, and no teeth are shown on the left plate. C) Third hypobranchial: bones shown in broken lines for orientation). Abbreviations: BH – basihyal; B1-4 – basibranchials 1-4; C1-5 – ceratobranchials 1-5; H1-3 – hypobranchials 1-3; E1-4 – epibranchials 1-4; ET2-3 – epibranchial tooth plates 2-3; I1-4 – infrapharyngobranchials 1-4; UP4 – upper pharyngeal tooth plate 4; IC – interarcual cartilage.

small block of cartilage), and a well-developed fourth upper pharyngeal tooth plate. Dermal tooth plates are present on the fifth ceratobranchial, second and third pharyngobranchials, and the second and third epibranchials. Both the interarcual cartilage and the uncinat process of the first epibranchial from which it extends are well developed. The ventral process on the third hypobranchial is long and curved (Fig. 9C), and the left and right processes are closely applied at the midline, thus enclosing the posterior portion of the third basibranchial. The fifth ceratobranchial is divided by a cartilage disk into two portions near its anterior end, ie, near the edge of the toothplate (this condition has been seen otherwise in only *Caranx*, although very good staining for cartilage is probably required for it to be visible).

### Discussion

Although *Lactarius* is usually considered either a carangoid or closely related to the group, some other views have been expressed. None of these withstand scrutiny. Günther (1860) noted some apparent similarities with sciaenids: as noted above, these are superficial only. Sasaki (1989) listed 15 synapomorphies to support the monophyly of the Sciaenidae (ignoring five myological and two otolith characters): *Lactarius* possess only one of these (an edentulous palatine). Regan (1913) implied a relationship with the serranids. However, *Lactarius* possesses none of the four derived character states used by Johnson (1983) to propose monophyly of the serranids. Seale's (1910) placement of *Lactarius* with the scombrids is not supported by recent work on scombroid relationships (Johnson, 1986). Nothing about the larval development of *Lactarius* would suggest a relationship to the sciaenids, serranids or scombrids. It was with this in mind that the carangoid fishes were investigated as the potential relatives of *Lactarius*. In addition, initial survey of larval and adult character states (the latter based primarily on Johnson, 1984, table 120) suggested that the carangoids were the best candidates among the Percoidei.

Johnson (1984) and Smith-Vaniz (1984) considered the interrelationships of the carangoid fishes as circumscribed by them (ie, Nematistiidae, Echeineidae, Rachycentridae, Coryphaenidae, Carangidae) and established monophyly of the group. There are several obstacles to attempting to evaluate the idea that *Lactarius* is related to the carangoids. First, the larval series of *Lactarius* is incomplete, and it is possible that important information remains to be ascertained from larvae less than 6 mm long. Second, it was not possible to study the developmental osteology of *Lactarius* because the few larvae available were in poor condition, and largely deossified. Therefore, homologies could not always be established. Third, larvae of the monotypic carangoid family

Nematistiidae are unknown. Fourth, there is no credibly hypothesised sister group for the Carangoidei except the vague assemblage of 'other percoids'. These ultimately combined to frustrate my attempts to perform a rigorous analysis of the relationships of *Lactarius*.

*Lactarius* cannot be considered a carangoid fish *sensu* Smith-Vaniz (1984) and Johnson (1984) because it lacks the two synapomorphies used by them to define the suborder: prenasal bones (Fig. 5C,D) and small, adherent, cycloid scales. However, it is worthwhile to set out the evidence hinting at a carangoid relationship, equivocal as it is, as a basis for further study. There are no unique, unreversed synapomorphies supporting such a relationship. With two possible exceptions the character states are either losses or conditions with distributions that indicate multiple, independent evolutions. These eight characters are listed and discussed below.

1) *Soft-rayed portion of the dorsal and anal fins long-based.* All the carangoid fishes and *Lactarius* have such fins, but so do a number of percoid and other perciform fishes. This is likely to be a derived condition in perciform fishes, but it has probably arisen several times. Probably, this is one of the elements of general similarity that prompted earlier authors to consider *Lactarius* a carangoid.

2) *Cycloid scales.* Cycloid scales are present in *Lactarius* and the carangoids. Johnson (1984) and Smith-Vaniz (1984) considered that within the Percoidei cycloid scales are derived, but have probably arisen several times. It remains to be shown that the large, relatively deciduous, cycloid scales of *Lactarius* are homologous with the small, adherent cycloid scales of the carangoids.

3) *Larvae lack subopercular spines.* Larvae of both *Lactarius* and the carangoids lack subopercular spines (for all larval characters, it must be remembered that larvae of the carangoid *Nematistius* are unknown). The presence of subopercular spines in percoid larvae is considered primitive by Johnson (1984), but these spines may have been lost independently several times as many percoid families lack them.

4) *Larvae lack interopercular spines.* Larvae of both *Lactarius* and the carangoids lack interopercular spines. The presence of interopercular spines in percoid larvae is considered primitive by Johnson (1984), but these spines are absent in several percoid families, and may have been lost more than once.

5) *Larvae have a series of melanophores along the dorsal midline of trunk and tail.* Larvae of *Lactarius* and the carangoids have such a pigment series (in some heavily pigmented 'echeineoids', this series cannot be seen: I have assumed it is present, but obscured by heavy overall pigment). This pigment series has almost certainly been derived more than once within the Percoidei. It occurs in some or all of the larvae of about 12 of the more than 80 percoid families, as well as some scombroids and pomacentrids.

6) *Hypurals 1 and 2 fused as are hypurals 3 and 4.*

Fusion of the hypurals in this manner occurs in *Lactarius*, and all the carangoids except Echeneididae and Rachycentridae. This fusion is considered derived in percoids by Johnson (1984), but as it is present in 25 percoid families, it is likely to have occurred several times.

7) *Coracoid with a broad anterior lamella broadly extending toward the cleithrum.* This sort of coracoid is found in *Lactarius* and all the carangoids except *Nematistius* and is considered derived by Johnson (1984) and Smith-Vaniz (1984). Of the eight characters suggesting that *Lactarius* and the carangoids are related, this is the most convincing, and it is considered further below. However, it occurs also in some non-percoid perciform groups including acanthuroids (Tyler *et al.*, 1989), 'squampinnes', mugilids and scombroids (A.C. Gill, personal communication).

8) *Ventral processes of third hypobranchials long and closely applied at the midline, enclosing the third basibranchial.* This sort of hypobranchial process is found in *Lactarius*, and most carangids examined: *Trachurus* (this study and Suda, 1991), *Decapterus*, *Pseudocaranx* and *Caranx*. In the carangid *Scomberoides*, the processes are moderate in length, but nearly touch at the midline, and in 'echeneoid' *Coryphaena* they are short and do not closely approach the midline. In a cursory survey of 21 other percoid genera of 17 families, I found long, closely applied ventral processes on the hypobranchials only in *Mene*. Markedly elongate processes which are not closely applied are present in *Pseudanthias*, *Epinephelus* and *Scorpiis*. Only in *Leiognathus* among the 21 genera are the processes closely applied, but here they are broad and almost round. The remaining taxa have short to moderately long processes that are not closely applied at the midline. So, the distribution of this character state is promising, but incompletely known, and it is not present in all carangoids (absent in *Coryphaena* and apparently different in *Scomberoides*).

All eight of these character states are also found in the monotypic percoid *Mene*, which also lacks the two carangoid synapomorphies: prenasal bones (Fig. 5B) and small, adherent, cycloid scales. It is possible that four additional derived character states are shared between *Mene* and *Lactarius*, but homology of all four is suspect. These are discussed next.

9) *Swim bladder extends posterior to the anus.* Posterior extensions of the swimbladder occur in *Mene*, *Lactarius* and within the carangoids, in some carangids. Such a posterior extension occurs in some or all members of at least 27 percoid families (Y. Tominaga and K. Matsuura, personal communication), and the structure of these posterior extensions differ substantially among taxa suggesting more than one derivation.

10) *Larvae lack spines on the supracleithrum.* Supracleithral spines are absent in the larvae of Lactariidae, Menidae, and within the carangoids only in

the 'echeneoids'. Absence of spines on the supracleithrum is considered derived in percoid larvae by Johnson (1984), but they are absent in many percoid families, and this loss has almost certainly occurred several times.

11) *Larvae lack spines on the posttemporal.* Posttemporal spines are absent in the larvae of Lactariidae, Menidae, and among the carangoids, in one 'echeneoid' family (Echeneididae). Absence of spines on the posttemporal is considered derived in percoid larvae by Johnson (1984), but these spines are absent in many percoid families, and this loss is also likely to have occurred more than once.

12) *Neural spines and arches 1 and 2 closely applied.* This condition occurs in the Lactariidae, Menidae, Nematistiidae and a number of other percoid groups (eg, some apogonids), and although it is probably derived, it apparently arose more than once. In addition, the arrangement of neural arches and spines and pterygiophores differs among these taxa, raising the question of homology. In *Lactarius*, the neural arches and spines are broad, and the pterygiophores are slender (Fig. 7). In *Mene*, all three are very slender, and the first neural spine is in some specimens ontogenetically captured by the second arch resulting in a bifurcate second neural spine (Fig. 10). In *Nematistius*, the first pterygiophore is very broad and apparently displaces and crowds together the first and second centra and neural spines (Rosenblatt & Bell, 1976, fig. 12).

In addition, *Mene* shares with the carangoids (but not *Lactarius*) six possible synapomorphies. None of these are unequivocal.

13) *Larvae lack opercular spines.* Larvae of *Lactarius* have an opercular spine: larvae of *Mene* and

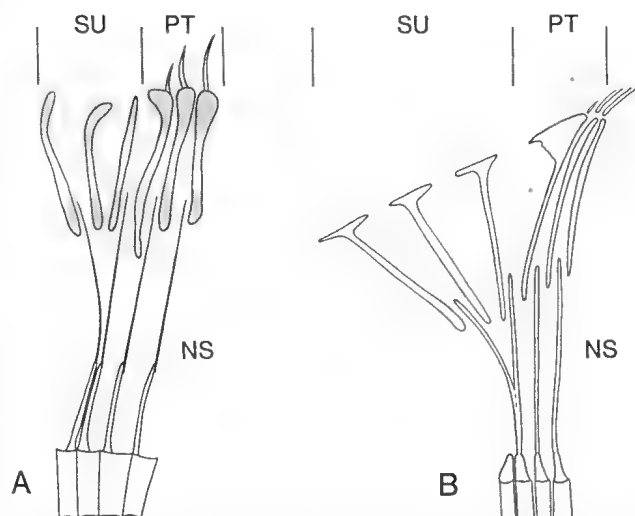


Fig. 10. Supraneurals (SU), anterior dorsal pterygiophores (PT), and neural spines (NS) of *Mene maculata*. A – larva (AMS unregistered, 4.3 mm SL); shaded areas are cartilage; B – adult (AMS I.15557-122, 70 mm SL), note bifurcate neural spine on centrum 2.

the carangoids lack an opercular spine. The absence of an opercular spine was considered derived in percoid larvae by Johnson (1984), but it is absent in many percoid families, and the loss probably occurred more than once. Some illustrations of larvae of the carangid genera *Trachinotus* and *Naucrates* appear to show opercular spines (eg, Laroche *et al.*, 1984, figs 272A,B), but the larvae available to me do not have opercular spines (see also Johnson, 1984, table 121).

14) *No radial cartilage anterior to neural and haemal spines of third preural centrum.* This cartilage is absent in *Mene* and the carangoids (present in *Lactarius*). The absence of this cartilage was considered derived in percoid fishes by Johnson (1984), but it is absent in many percoid families, and this loss may have occurred more than once.

15) *Procurent caudal spur absent.* The procurent spur is absent in *Mene* and the carangoids (present in *Lactarius*). Johnson (1984) considered that in percoids its absence is derived, but it is absent in many percoid families, and this loss may have occurred more than once.

16) *Larvae have a supraoccipital, usually serrate, crest.* A supraoccipital crest is present in the larvae of *Mene* and nearly all carangids, but among the carangoids it is absent in the 'echeneoids' and larvae of *Nematistius* are unknown (it is absent in *Lactarius*). This type of larval spination was considered derived by Johnson (1984), but as it occurs in all or some of the members of 14 other percoid families, it may have been derived more than once.

17) *Three or fewer tri-segmental pterygiophores in both dorsal and anal fin.* *Mene* and the carangoids have three or fewer tri-segmental pterygiophores (*Lactarius* has 3-5 dorsal and 2-3 anal tri-segmental pterygiophores). According to Johnson (1980:35), the reduction in number of tri-segmental pterygiophores is derived. However, many percoid families have a reduced number of tri-segmental pterygiophores, and he argued that this reduction has "occurred along several independent lines."

18) *Larvae have a midlateral series of melanophores on the tail.* Larvae of *Mene* and the carangoids (but larvae of *Nematistius* are unknown) have this melanophore series. This melanophore series is found in only about 12 of the more than 80 percoid families, and is probably derived within the percoids, but may have arisen more than once. This pigment series is absent in all the *Lactarius* larvae studied here, but it could be present in larvae smaller than 6.0 mm, the smallest specimen available.

*Lactarius* is an unusual fish with a number of autapomorphies. Most of the relationships suggested for *Lactarius* were based on superficial resemblances, shown since to be invalid (see above). In contrast, the carangoid relationship cannot be rejected. However, it is hard to obtain unequivocal evidence to support that, or any other, relationship.

The characters summarised above provide some evidence that *Lactarius* and *Mene* are, respectively, second and first sister taxa of the carangoid fishes *sensu* Smith-Vaniz and Johnson. Unfortunately, only two of the 18 characters (numbers 7 and 8) provide evidence not tainted by possible multiple origins within the percoid fishes, losses, or lack of knowledge of either small larvae of *Lactarius* or any larvae of the carangoid *Nematistius*. It must be remembered that the 'carangoid' state of character 7 occurs in some non-percoid perciform groups. Therefore, it is worth examining character 7 to see if it is a strong, central support of a carangoid relationship to which the other, equivocal characters can be added for mutual support, or merely another equivocal element.

Smith-Vaniz (1984) described the coracoid in carangids and 'echeneoids' as "middle part of coracoid with its anterior margin consisting of a lamella of bone broadly extending toward the median cleithral wing". This was not illustrated by him, but reference was made to illustrations of Suzuki (1962). Smith-Vaniz (1984) stated "in *Nematistius* the middle and lower parts of the coracoid are rodlike with lamellar bone restricted to its posterior margin", and referred to illustrations of Rosenblatt & Bell (1976). Johnson (1984) described the coracoid of carangids and 'echeneoids' as having a "lamellar expansion along the anterior margin of the coracoid" and the coracoid of *Nematistius* as being "unmodified". He provided neither figures nor references to any.

The coracoids of *Lactarius* (Fig. 6A) and *Mene* (Fig. 6B) are described accurately, if imprecisely, by the text portrayals of Smith-Vaniz (1984) and Johnson (1984). The shape and extent of the anterior lamella varies greatly among the carangids illustrated by Suzuki (1962) and examined by me, and this variation encompasses the coracoid lamella morphology of both *Lactarius* and *Mene*. The coracoid of *Nematistius* as illustrated by Rosenblatt & Bell (1976) is not encompassed within the carangid morphologies illustrated by Suzuki, and is similar to the coracoid of more generalised percoid fishes such as *Lutjanus* (Potthoff *et al.*, 1988).

Therefore, I tentatively consider *Lactarius*, *Mene*, carangids and 'echeneoids' to have the same derived coracoid character state, one that differs from the apparently primitive condition of *Nematistius*. Unfortunately, this cannot be confirmed until the ontogeny of this bone is studied in all the taxa in question: at present this has been done only for the 'echeneoid' family Coryphaenidae (Potthoff, 1980). The occurrence of a similar coracoid morphology in acanthuroids and some other groups and the apparent lability of coracoid morphology within the carangids seemingly lessens the assurance that this character is a robust indicator of relationships.

The distribution of character 8 (ventral processes of third hypobranchials long and closely applied) is too poorly known at present to determine if it, too, is an equivocal indication of relationships. Further work is

required to evaluate this character state and its distribution. If it is confirmed to be confined to carangoids, *Lactarius* and *Mene*, it would be strong support for the hypothesis that these taxa are monophyletic. However, the apparent absence of this state in the 'echeneoid' fishes (at least *Coryphaena*) does present a problem for that hypothesis.

If *Lactarius* and *Mene* are included with the carangoids on the strength of characters 7 and 8 there are two possibilities. Either *Lactarius* and *Mene* are the primitive members of the superfamily and there is a reversal in *Nematistius* to the primitive coracoid condition, or *Nematistius* is the sister group of the other carangoids, and there is a loss in both *Lactarius* and *Mene* of the prenasal bone and the small, adherent scales. The former is more parsimonious. However, until the larva of *Nematistius* are described, and more larvae of *Lactarius* become available, the situation will remain unresolved.

Four characters (9, 10, 11, 12) indicate that *Lactarius* and *Mene* are sister taxa. Losses are involved in two of these (10, 11), and one involves a possibly misinterpreted homology (12). The fourth (9) involves posterior extension of the swim bladder, and this differs in construction in the two taxa, so there is additional doubt about homology. Therefore, the evidence for the two taxa being sister groups is not strong.

In conclusion, placement of *Lactarius* and *Mene* in the carangoid fishes or as successive sister groups to the carangoid fishes is suggested by several demonstrably equivocal characters and two characters of uncertain reliability. The inclusion of *Lactarius* and *Mene* with the carangoids must be considered a tentative hypothesis, and evidence from larvae will be crucial to testing it. Study of larvae is required to determine the states of several characters in *Nematistius* larvae and in small *Lactarius* larvae (once these become available), and to determine by examination of ontogeny if characters such as the coracoid lamella are homologous among the taxa studied here. A study of the distribution of character eight (ventral processes of third hypobranchial) among percoid fishes is also required.

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## A Revision of the Genus *Uromys* Peters, 1867 (Muridae: Mammalia) with Descriptions of Two New Species

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**ABSTRACT.** *Uromys* Peters, 1867 is re-defined so that it is monophyletic. The clade includes nine species placed in two monophyletic subgenera: *U. (Cyromys)* includes the species *porculus*, *rex* and *imperator*; *U. (Uromys)* includes the species *anak*, *neobritannicus*, *hadrourus*, *caudimaculatus*, *emmae* n.sp. and *boeadii* n.sp. *Uromys (Cyromys)* includes more plesiomorphic species, which are all restricted to Guadalcanal in the Solomon Islands. Species of *U. (Uromys)* are more derived, as in their possession of greatly simplified molars, and in having the number of interdental ridges of the soft palate greatly multiplied. The genus is widespread in Melanesia and northern Australia. Three distinct subspecies of *U. caudimaculatus*, and three of *U. anak* (one new) are recognised. *Uromys boeadii* n.sp., from Biak Island, and *Uromys emmae* n.sp., from Owi Island, both in Geelvinck Bay, are newly described.

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The generic name *Uromys* was proposed by Peters, 1867 for *Mus macropus* Gray, 1866. *Mus macropus* is a primary homonym (*nec* Hodgson), and thus the first available name for the species is *Hapalotis caudimaculatus* Krefft, 1867. Until 1922 all mosaic-tailed rats from Australasia were referred to the genera *Uromys* or *Mus*. In 1922, however, Thomas divided the species previously assigned to *Uromys* between three genera: *Uromys*, *Melomys* and *Solomys*. He defined the members of his newly restricted genus *Uromys* as follows: size large (hindfoot length greater than 52 mm,

skull longer than 70 mm), tail long, incisive foramina short, bony palate extends to behind M<sup>3</sup>, incisors deep, and ridges of the soft palate duplicated and up to 12 in number. He included in *Uromys* only taxa currently recognised as belonging within the species *caudimaculatus* and *anak*.

Rümmler (1938) was the next major reviser to deal with the genus as a whole. He differentiated the species of *Uromys* from other New Guinean murids by their possession of a high infraorbital canal which narrows to a slit-like base, wide maxillary plate, simple molars and

a practically hairless tail whose scales have a raised hump. He further noted that the species of *Uromys* were larger than the species of *Melomys*, and that the bony palate extended further posteriorly in *Uromys*. He included the species *anak*, *salamonis*, *imperator*, *caudimaculatus* and *neobritannicus* within the genus.

Tate (1951) was the most recent comprehensive reviewer of the genus *Uromys*. Synonymising *Solomys* with it, he defined it as follows: tail with one hair per tail scale, tail long and feet scansorial; more or less pronounced postorbital ridging, incisive foramina short, palate short (an error for long?), bulla small, incisors massive, molars simple, skull massive with uninflated braincase. He included the species *anak*, *caudimaculatus*, *sapientis*, *salebrosus*, *rex*, *imperator*, *porculus*, *salamonis* and *ponceleti* within *Uromys*. As part of their checklist of the mammals of the New Guinean and Sulawesi regions, Laurie & Hill (1954) included only the species *caudimaculatus*, *anak*, *neobritannicus*, *rex*, *imperator* and *salamonis* within *Uromys*, referring *porculus* to *Melomys*, and *sapientis*, *salebrosus* and *ponceleti* to *Solomys*.

The concept of *Uromys* has thus been highly unstable over the last century. The principal reviewers have, however, always included a core of two species, *caudimaculatus* and *anak* within it; other large murid species from Melanesia have been variously included and excluded with little apparent attempt at determining phylogenetic relationships.

Quite apart from problems of defining the genus, there has been a wide diversity of opinion among

workers regarding species limits and subspecies concepts for some of the included taxa. Without doubt, that with the least stable taxonomic history is *Uromys caudimaculatus* and its various named races. As previously constituted, this species has a wide range (Fig. 1) and great degree of morphological diversity. Thomas (1922) recognised seven distinct species (*aruensis*, *macropus*, *multiplicatus*, *nero*, *papuanus*, *scaphax* and *validus*) which later workers have regarded as belonging within *U. caudimaculatus*. Rümmler (1938) recognised six subspecies of *caudimaculatus*: *caudimaculatus* and *sherrini* from Queensland, *seibersi* from the Kei Islands, *aruensis* from the Aru Islands, *validus* from New Guinea and nearby Islands, and *barbatus* from montane New Guinea. Tate (1951) showed that the last of these taxa in fact belongs within a monotypic genus (*Xenuromys*), which is not closely related to the *Uromys/Melomys* complex, and recognised only the subspecies *caudimaculatus*, *aruensis* and *multiplicatus*, in which he was followed by Laurie & Hill (1954).

Our concept of *Uromys* differs from that of all previous workers. We recognise a group of nine species that on the basis of a suite of shared derived characters forms a monophyletic group, here recognised as the genus *Uromys*. We further recognise two monophyletic subgenera: the more plesiomorphic *Cyromys* and the more derived *Uromys*. We divide specimens previously allocated to *U. caudimaculatus* between three subspecies, and describe a new, related species based upon hitherto unexamined material; we divide *U. anak*

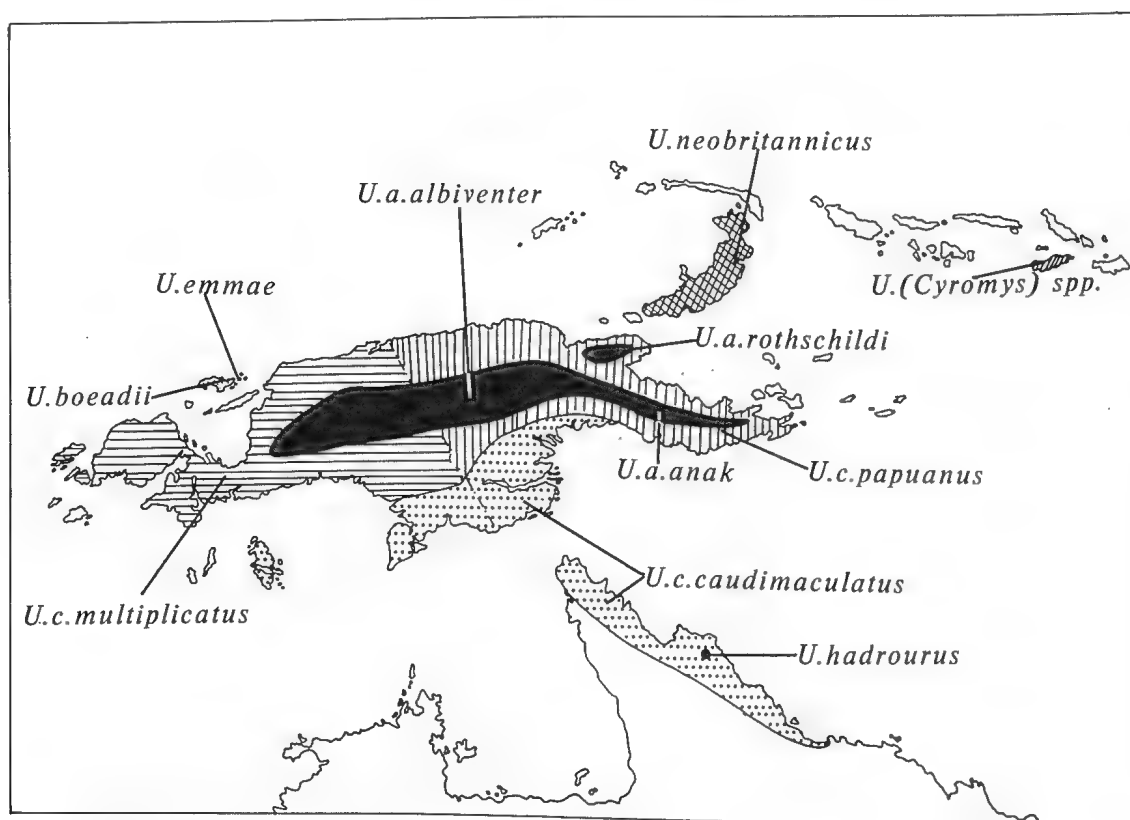


Fig. 1. Map of the New Guinean region showing the approximate distribution of the species and subspecies of *Uromys*.

into three subspecies (one of them new); and we describe a new species of uncertain affinities.

### Materials and Methods

During the course of this study we have examined all material referable to the species of *Uromys* held in the Natural History Museum (London), the Bishop Museum (Hawaii), the Rijksmuseum van Natuurlijke Historie (Leiden), the Australian National Wildlife Collection (Canberra), the Queensland Museum (Brisbane), the Museum of Victoria (Melbourne) and the Australian Museum (Sydney) (for list of localities for *U. caudimaculatus* and *U. anak* see Table 1 [Appendix]). In particular we have examined the holotypes or syntypes of all named taxa except *Uromys papuensis* Ramsay (which cannot be located among the collections of either the Australian or Macleay Museums, where it can reasonably be expected to have been lodged), *Uromys neobritannicus* Tate & Archbold, and *Uromys waigeouensis* Frechkop. One of us (TFF) also briefly examined material in the American Museum of Natural History, New York; more detailed examination at a later time will enable our conclusions to be more extensively documented, but as it is clear that this material does not affect the conclusions, we do not think it advisable to hold up this revision.

The following abbreviations are used: AM M and AM S – Australian Museum mammal specimen; BM – Natural History Museum mammal specimen; BBM – Bishop Museum; CM – National Wildlife Collection mammal specimen; NMV – Museum of Victoria Mammal Specimen. All tables in this paper are listed in the Appendix.

We took a number of measurements on each specimen; unfortunately, time precluded taking our full list on every single specimen, but in all cases greatest skull length (maximum: nuchal surface to anterior edge of premaxillae or nasals), condylobasal length, bizygomatic breadth and maxillary tooth row length were measured, and any flesh measurements recorded on the specimen label were noted. As well as normal univariate comparisons, we calculated certain simple indices (tail as percent of head + body; ear as percent of condylobasal length). We also performed a number of multivariate analyses, using SPSS-X Discriminant Functions programs. We used Direct method for all analyses, and for comparative purposes both Mahalanobis and Rao methods in one case; the results for all three methods are very close. We performed three analyses. (i) All species of *Uromys* except for *U. emmae* n.sp. and *U. boeadii* n.sp., using the following variables: greatest skull length, condylobasal length, anterior skull height (perpendicular to posterior margin of palate), anterior zygomatic width (between most convex points on zygomatic process of malar bones), posterior zygomatic width (maximal bizygomatic width), rostral height (perpendicular to premaxillary/maxillary

suture on palate), braincase breadth, rostral length (anterior orbit margin to prosthion), rostral breadth (across rostrum on premaxillary/maxillary suture). (ii) *Uromys caudimaculatus* and *U. emmae*, using the following variables: greatest skull length, condylobasal length, posterior zygomatic width, head + body length, tail length, hindfoot length, ear length (samples are listed in Tables 1-2). (iii) *Uromys anak* and *U. boeadii*, using the same variables as listed in analysis 2 (samples are listed in Tables 1-2). Note that only variables subject to ontogenetic change were included, ie, tooththrow length was not incorporated as being liable to distort the results. In order to exclude, or at any rate minimise, discrimination by size alone, subadults as well as adults were included in each sample; this at the same time avoids discrimination on the basis of chance differences in age or sex composition between samples. In all but these cases, we ensured that the number of specimens in each sample was greater than the number of discriminating variables. The three exceptions were *U. boeadii* and *U. emmae*, for which there was but a single specimen each, and *U. hadrourus*, for which there were two adult skulls. The composition of our samples in the analyses was determined by prior inspection, ie, we were concerned to test the validity of our taxonomic assessments in a morphometric analysis.

We finally performed a cladistic analysis using (i) Hennig86 (using, out of the 49 characters found to be distinctive of species within the genus [Table 3], those 41 in which more than one taxon showed the derived condition), and (ii) MacClade (Wayne & David Maddison), using all 49 characters. Hennig86 is a basic cladistic program which finds all the most parsimonious trees; MacClade is a tree manipulation program; when the basic outlines of *Uromys* phylogeny were clear, we wished to examine the effect of different placements of certain key taxa, especially *U. boeadii*. The default parameters were used for these computer programs, including ordered variables for Hennig 86. *Melomys rufescens* was used as an outgroup.

### Systematics

#### *Uromys* Peters, 1867

**Type species.** *Hapalotis caudimaculatus* Krefft, 1867.

**Revised generic diagnosis.** The species of *Uromys* can be differentiated from all other murids in possessing the following combination of features: i) soft palate has between six and 12 irregular ridges in region between molar rows (Fig. 2); ii) palate extends posteriorly beyond posterior margin of M3; iii) lower incisors much deeper than wide; iv) anterolateral spine of bulla greatly expanded.

**Notes.** McAllen & Bruce (1989) suggest that *Melanomys* is a new generic name proposed by

Winter (1983) for the species *hadrourus*. This name results from a typographical error in a reference, and in any case is preoccupied by *Melanomys* Thomas, 1902.

The generic diagnosis differentiates *Uromys* from all other Muridae, including its close relatives *Solomys* and *Melomys*, with which it agrees in possessing a so-called mosaic tail (described, for example in Tate, 1951). Species of *Uromys* differ additionally from species of *Melomys* in their larger size, and from species of *Solomys* in lacking the latter's greatly thickened palate, and by the relatively larger, thicker incisors, more elongate basoccipital, and the posteriorly broadened

palate. We transfer to *Uromys* two species previously referred to *Melomys* (*M. porculus* and *M. hadrourus*), and transfer *salamonis*, previously placed within *Uromys*, to *Solomys*.

The Discriminant Analysis (Fig. 3) discriminated the quasi-specific samples on the basis of (first function, accounting for 42.5% of total variance) greatest skull length and snout length, and (second function, 35.9% of variance) overall size except for braincase breadth. A third function accounted for 12.3% of variance, but was an absolute size discriminator, distinguishing only *U. hadrourus* effectively. The two subgenera are not sharply distinguished by the analysis: *U. caudimaculatus*,

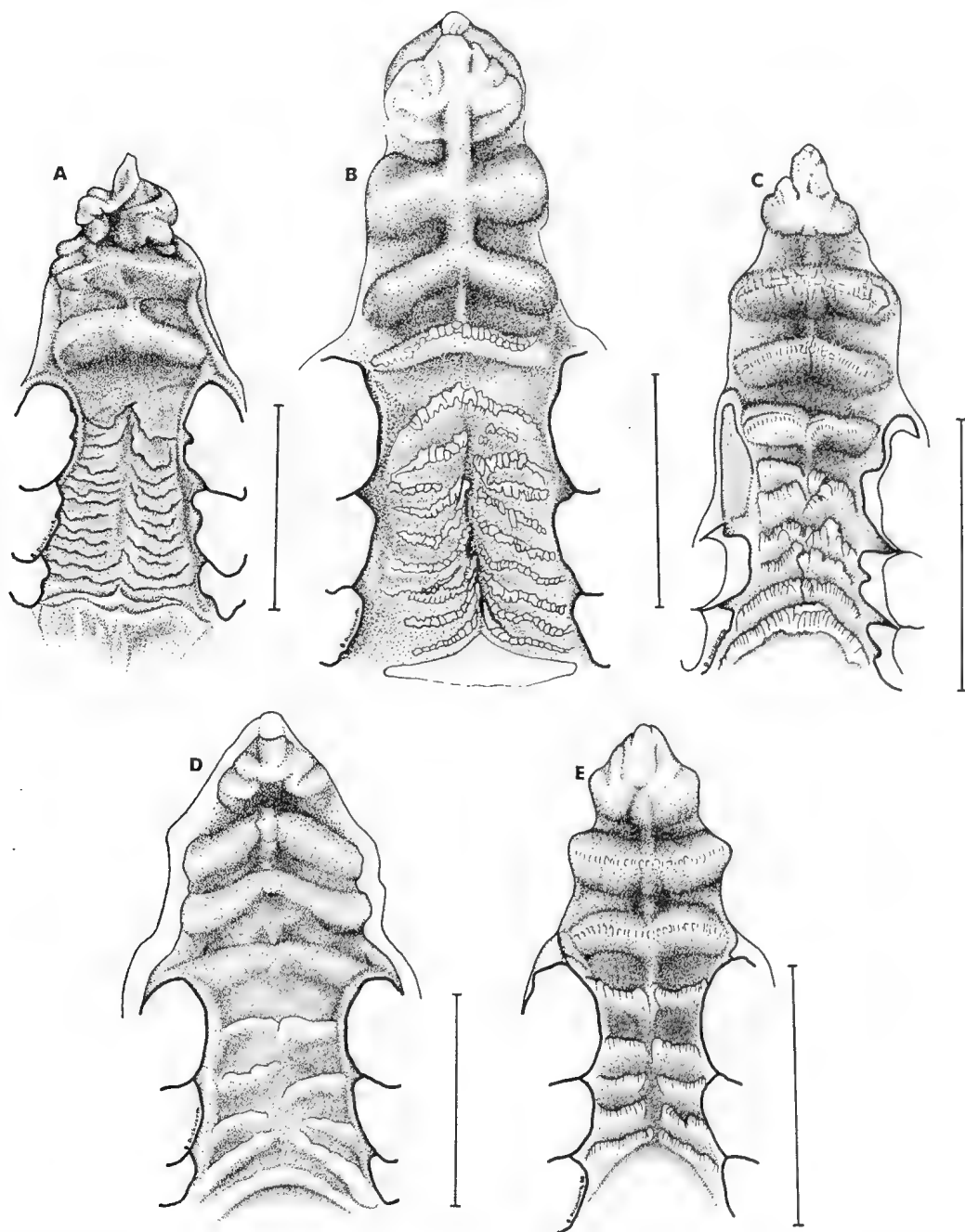


Fig. 2. The soft palate of (A) *Uromys caudimaculatus*, (B) *U. anak*, (C) *U. rex*, (D) *Xenuromys barbatus* and (E) *Solomys sapientis*.

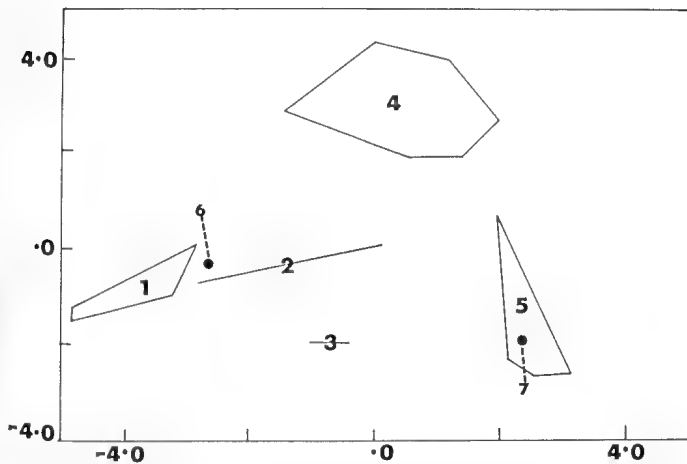


Fig. 3. Discriminant analysis of *Uromys*. Function 1 (abscissa) accounts for 42.5% of the total variance, and is most highly correlated with greatest skull length and snout length; Function 2 (accounting for 35.9% of total variance) is positively correlated with all variables except braincase width. 1 = *U. rex*, 2 = *U. imperator*, 3 = *U. hadrourus*, 4 = *U. anak*, 5 = *U. caudimaculatus*, 6 = *U. porculus*, 7 = *U. neobritannicus*.

*U. hadrourus* and *U. anak* are arrayed around one end of a linear clinal spread from *U. rex* via *U. porculus* to *U. imperator*. The result is difficult to interpret, but is consistent with our conclusions (below) that *U. rex* is the most autapomorphic species in *U. (Cyromys)* and that *U. anak* is less like other species of *U. (Uromys)* than is *U. neobritannicus*.

### *Uromys (Cyromys)* Thomas, 1910

**Type species.** *Mus imperator* Thomas, 1888.

**Revised diagnosis.** The species of *Uromys (Cyromys)* can be distinguished from species of *U. (Uromys)* by possessing the following features: i) molar rows relatively short, molars relatively broad; ii) M3 larger relative to other teeth; iii) anterior lophid of  $M_1$  distinct even in worn molars; iv) molars more complex, individual cusps more distinctly defined, with  $M^1$  retaining a well-developed fossa lingual to posterior cingulum; v) anterior and ventral orbital walls slope away from centre of orbitotemporal fossa, so that walls can be seen in dorsal view; vi) frontotemporal sutures markedly ridge-like; vii) coronal suture strongly convex or biconvex backwards; viii) preorbital foramen slopes backwards, so that inferior margin readily visible in dorsal view; ix) ascending ramus flares laterally; x) tail scales consist of small central prominence surrounded by large fleshy area. All of the dental features listed here are probably plesiomorphic for the species of *Uromys* and closely related genera (see discussion). However, the tail morphology is unique among near relatives and is presumably synapomorphic for the subgenus.

Additional useful diagnostic features for the

subgenus are as follows. The rostrum is broad, and the incisive foramina are strongly bowed outward; although the temporal sutures are markedly ridge-like, there are no post-sutural processes. The nasals are posteriorly broadened, and the posterior part of the lateral walls of the rostrum are steep, nearly vertical and partially concealing the lachrymal in dorsal view. The zygomatic arches do not swing down to the level of the molar alveoli. The nasal tips are abbreviated and slightly downturned. The incisors are opisthodont. The paroccipital processes are long, their tips level with the inferior margins of the occipital condyles and the auditory bulla. The insertion scar of the *M. temporalis* on the mandible is marked by a strong anterior ridge.

Although *U. (Cyromys)* differs strongly from *U. (Uromys)*, and a good case could be made for separating them generically, we prefer at least for the present to retain them in one genus in order to emphasise their sister-group status with respect to their closest relatives (*Melomys*, *Solomys*).

### *Uromys (Cyromys) imperator* (Thomas, 1888)

**Type material.** HOLOTYPE, BM 88.1.5.33, adult female skin and skull collected at Aola, northern Guadalcanal, Solomon Islands, by C.M. Woodford.

**Revised diagnosis.** *Uromys (Cyromys) imperator* is the largest of the species of *Cyromys*. The pads of the feet are reduced in size relative to other *Cyromys*, and the molars relatively much broader. It is similar externally to *U. rex*, with its dark grey, somewhat woolly fur (as aptly described by Thomas, 1888), grading to white below, and its very short ears. In comparison with *U. rex*, however, the head and body is longer, and the tail shorter with smaller scales (9–11 per cm versus 7–9 per cm). The skull is characterised by a median posterior palatal spine; very square posterior nasals which end comparatively far forward, anterior to a line connecting the posterior ends of the lachrymals; a relatively vertical ascending ramus with a low, rounded coronoid process; and a small dentary ridge and tubercle.

**Discussion.** *Uromys imperator* is still known with certainty only from the original three specimens collected by Charles Woodford at Aola on Guadalcanal in 1887. Woodford probably purchased the specimens from local hunters, and it is unlikely that they were collected far from the coast as Woodford (1890) mentions repeatedly the near impossibility of travelling far inland for fear of neighbouring tribes. A flat skin without a skull in the Australian Museum (AM M19739) may, however, also represent this species. Its tail scales are less rasp-like than the Museum's specimens of *U. rex*, and the size is considerably larger, although smaller than the previously known specimens of *U. imperator*. It was collected by a Captain G. Hart. Other specimens collected by Captain Hart in the Museum Collections are from Lavoro Plantation in far northern

Guadalcanal, and were collected in August 1933. On balance, we think this likely to be *U. rex* because of the larger foot pads, but the difficulty of identification reinforces our conclusion that the two species are extremely close.

Recently the remains of *U. imperator* have been found in archaeological deposits in northern Guadalcanal (Flannery & Roe, in preparation). Extensive questioning of the older people of Guadalcanal suggest that it may well be extinct, there having been few or no reliable sightings over the last 40 years, and also suggest that within living memory it was encountered only in montane mossy forest. This is surprising, considering that the archaeological deposits within which its remains have been found are now located in savannah areas near sea level, far distant from any mossy forest, and that Woodford's specimens probably came from near the coast.

Because of its short tail and reduced pads on the feet, Thomas (1888) considered this species to be terrestrial. This hypothesis is strengthened both by information related to one of us (TFF) by older men who had seen it in their youth, and from an examination of the adult male in the Natural History Museum specimen (BM 1888.1.5.32) which has considerable amounts of clay and earth adhering to the claws, forepaws and muzzle, suggesting that it was dug from a burrow.

### *Uromys (Cyromys) rex* (Thomas, 1888)

**Type material.** HOLOTYPE, BM 88.1.5.34, adult male skin and skull collected at Aola, Guadalcanal, Solomon Islands by C.M. Woodford.

**Revised diagnosis.** Larger than *U. porculus* but smaller than *U. imperator*. Differing further from *U. imperator* in its relatively narrower molar rows and shorter, broader skull with an especially broad, deep rostrum; its extreme development of the frontotemporal ridges; the more arched posterior nasal ends which are level with the posterior ends of the lachrymals; the absence of a post palatal spine; the very oblique ascending ramus with strongly-developed tubercle and ridges, and slender, pointed coronoid. Externally it differs in its longer tail, larger pads on the hindfeet, and larger, more rasp-like tail scales (7-9 per cm versus 9-11 per cm).

**Discussion.** *Uromys (Cyromys) rex* is the only species of *U. (Cyromys)* for which the soft palate is known (Fig. 2). AM M19740 is an aged individual which shows an intriguing soft palate configuration. There are seven interdental ridges, as opposed to the five that are seen in the species of *Melomys* and *Xenuromys*. The interdental ridges are, however, irregular and incomplete. The increased number of ridges is clearly apomorphic and reminiscent of the

condition of *U. (Uromys)*, where between 10 and 12 interdental ridges can be present. Their irregularity and incompleteness in the only specimen of *U. (Cyromys)* thus far known, however, does not resemble the condition in *U. (Uromys)*. We are unsure of how to interpret this feature. It may be pathological (the animal is extremely aged), or it may be the normal condition, in which case it must be regarded as a synapomorphy for *U. (Cyromys)* or *U. rex*. Within *U. (Cyromys)*, *U. rex* is the most derived of the three species in many respects, despite its superficial resemblance to *U. imperator*.

The original series of seven specimens were collected at Aola by Woodford in 1887. The greater numbers of this species relative to the other two species of *Uromys* found on Guadalcanal by Woodford may suggest that even at this time it was the commonest taxon. It is the only one of the species of *Uromys (Cyromys)* to have been collected since Woodford's work. The Australian Museum holds a specimen in alcohol with the skull extracted (AM M13594) which was collected on Guadalcanal. Unfortunately, it lacks other data. A flat skin (AM M19739) belonging either to this species or *U. imperator* (see above, under *U. imperator*) is also held in the Australian Museum. There are two specimens (skins with skulls) in the Bernice P. Bishop Museum, Honolulu, Hawaii, USA (BBM 23988 and 24101), collected at Tabila, Guadalcanal, in June, 1964, by Peter Shanahan.

*Uromys rex* is still to be found on Guadalcanal, the most recent known specimen (AM M19746) being collected by one of us (TFF) in a relict outlier of tall rainforest in the Poha Valley north of Honiara in 1987. It was climbing a liane high in the canopy when sighted. In its size, external morphology and habits it is convergent upon *Solomys sapientis* and *S. salebrosus*. It seems plausible that this species has been able to survive because of its arboreal habits while the terrestrial *U. (C.) imperator* has evidently become extinct.

### *Uromys (Cyromys) porculus* (Thomas, 1904)

**Type material.** HOLOTYPE, adult male BM 89.4.3.8, collected at Aola, Guadalcanal, by C.M. Woodford.

**Revised diagnosis.** Smaller than any other species of *Uromys (Cyromys)*, and brown rather than grey above with fur not woolly in texture; also unique by virtue of its possession of grey based belly fur and in having a more finely scaled tail (13-14 scales per cm). The skull is longer and narrower than in *U. rex*, and the molars relatively narrower than in *U. imperator*. It differs additionally from *U. rex*, and resembles *U. imperator*, in its less prominent frontotemporal ridges and its subvertical ascending ramus, and from both *U. rex* and *U. imperator* in its more nearly parallel zygomatic arches and broad-arched nasofrontal suture.



**Discussion.** Although the only known specimen was described in 1904, the date of registration (1889), and the fact that it was collected by Woodford at Aola, suggest that this specimen was probably collected at the same time as the original *U. rex* and *U. imperator* material or shortly thereafter. The very short tail of this species suggests that it may have been terrestrial. Questioning local people by one of us (TFF) reveals that today there is no clear local knowledge of this species, and it is probably extinct. If this is so, then evidently both terrestrial species of Guadalcanal *Uromys* are probably now extinct, while the only arboreal species survives.

The only known skull of *U. porculus* has the molars so worn that few details of the crown remain. The soft palate is unknown. We assign it to *Uromys* (*Cyromys*), rather than to *Solomys*, for the following reasons. The anterolateral spur of the bulla is very large, as is typical of the species of *Uromys*, but not *Solomys* or *Melomys*. This enlargement of the anterolateral spur of the bulla appears to be synapomorphic of *Uromys* if any other of the Melanesian mosaic-tailed murid genera (*Melomys*, *Solomys*, *Pogonomelomys*) is taken as an outgroup. A second feature typical of the species of *Uromys* is that the bony palate extends to a level near the posterior end of  $M^3$ . This is also a derived condition for *Uromys*, being unknown in other mosaic-tailed rats. Furthermore, the palate shows no sign of thickening or the development of a large post palatal spine as is seen in the species of *Solomys*. The skull is elongate and narrow (a common feature in *Uromys*). As *U. porculus* shows no derived features typical of other Melanesian murid genera, we are confident that we are correct in placing it within *Uromys*. The placement within *Uromys* (*Cyromys*) is somewhat more problematic; but it lacks all of the derived features for *U. (Uromys)*, and possesses the apparently derived states of the orbitotemporal fossa, frontotemporal and coronal sutures, preorbital foramen and ascending ramus orientation which characterise *U. (Cyromys)*. Also, the tail scales are widely spaced, mainly flat but slightly raised distally, rounded or bluntly pointed, and some have one to three longitudinal ridges. Within the subgenus it clearly retains primitive features in its external morphology and the morphology of the zygomatic arches and posterior nasals. Cladistically, it is the sister taxon to *U. rex* and *U. imperator*.

#### *Uromys (Uromys)* Peters, 1867

**Type species.** *Mus macropus* Gray, 1866 (= *Hapalotis caudimaculatus* Krefft, 1867).

**Revised diagnosis.** The species of *Uromys (Uromys)* can be distinguished from the species of *Uromys (Cyromys)* by possessing the following features: i) incisive foramina very shortened, narrow, slit-like; ii) molars simple and elongated,  $M^3$  greatly reduced in size; iii) bony palate greatly lengthened posteriorly;

v) interdental ridges multiplied, with more than seven, and as many as 12 present; vi) anterior cingulum of  $M^1$  greatly reduced, obliterated on only moderately worn teeth; vii) cranial characters listed under *U. (Cyromys)* primitive in their states in *U. (Uromys)*.

The following additional features are also useful in identifying species of the subgenus *U. (Uromys)*. The lingual marginal ridges of the molar alveoli are enlarged. There are no frontotemporal ridges, but laterally directed processes of varying size are present behind the sutures. The medial and anterior walls of the orbitotemporal fossa are vertical, as is the preorbital foramen. The posterior ends of the nasals are not broadened, the zygomatic arches swing down to the level of the molar alveoli, the nasals slightly protrude anterior of the premaxillae, the incisors are orthodont, the paroccipital processes are short (not descending lower than the inferior margin of the external auditory meatus), the ascending rami of the dentary do not flare laterally, the tooththrows are comparatively well spaced.

#### *Uromys caudimaculatus* (Krefft, 1867)

**Type material.** SYNTYPE, AM S1848, skull only (the body apparently being lost). Cape York.

**Revised diagnosis.** *Uromys caudimaculatus* differs from *U. anak* and *U. neobritannicus* in possessing a posterior palatal spine, an only rudimentary postorbital process; narrow, tapering posterior nasals which terminate anterior to the posterior ends of the lachrymals; in having the hindfoot not usually longer than 22% of the head-body length and ear length more than 43% of condylobasal length; the incisive foramina are more than 20% of the palatal length, while the tooththrow is less than 20% of condylobasal length. The colour is a medium brown-grey, the feet are white, the tail scales arranged in clear rings and longer than broad, with a white tail tip. It differs from *U. hadrourus* in its larger size, less inflated braincase, and larger postorbital process and anterolateral bullar spurs, shorter ears and longer white tail tip, greater frontal convexity, narrower feet and less posteriorly extensive nasals. It differs from *U. emmae* n.sp. in its more elongate rostrum, narrower and longer hindfoot, relatively smaller teeth, longer ears, more inflated frontals, and in having the distalmost portion of the tail white.

**Notes.** We have considered whether there might not be two or even three distinct species among what was hitherto called *U. caudimaculatus*. As far as the mainland (Australian and New Guinean) forms are concerned, this might be possible. The work of Donnellan (1989), based upon chromosomes, suggests that these populations may represent distinct species, since a possible rearrangement (tandem fusions) in the Australian population should provide barriers to gene

flow. C-banding in the New Guinean population, however, is necessary before tandem fusion can be identified with certainty. A morphological study also shows that a distinct form inhabits Australia and southern New Guinea as far east as Kaimare in the Gulf of Papua, a second homogeneous taxon is found throughout the rest of the eastern half of New Guinea, and a third form is found in the western part of the island. Unfortunately, the characters that support this division are not entirely consistent, and when the insular populations are taken into consideration they form such a complex mosaic pattern that it is impossible to allocate the insular forms satisfactorily to one or other of the mainland species. Thus, while recognising the striking differences between the three mainland forms, and the lack of intermediates in some regions on the mainland, we have declined to recognise them as full species, but instead regard them as subspecies. Study of further material will be necessary to confirm or refute this hypothesis.

The Discriminant Function analysis (Fig. 4) tends to separate the three major mainland groups, but not cleanly. Clustering with the Australian/south New Guinea sample are specimens from Yapsiei and Yapen Island, and an Aru Islands specimen is in the slight overlap zone between the Australian/south New Guinean and the main Papua New Guinean samples. The Irian Jayan samples are close to one another, but a specimen from Kaimare (which in most respects apart from its metrical characters resembles the Australian form) falls within the Irian Jayan cluster. The only taxon recognised here as a full species that does fall cleanly outside any major cluster is the holotype of *U. emmae* n.sp.

Within Papua New Guinea there is a series of overlapping clusters: Mount Hagen area/south-east Papua/Mount Sisa/Dobodura. Specimens from Telefomin and Mount Karimui fall on the edge of the Mount Hagen cluster; one from the Torricelli Mountains falls, curiously, with the Mount Sisa specimens. One Mount Elimbari specimen falls outside any of these. Within Irian Jaya there is again a gradient: Alkmaar district/Setakwa/Mimika River/Utakwa, with a specimen from the Weyland Range falling, oddly, in the Papua New Guinea cluster.

*Uromys caudimaculatus caudimaculatus*  
(Krefft, 1867)

**Synonyms.** *Mus macropus* (Gray, 1866) (not of Waterhouse); *Uromys aruensis* Gray, 1873; *Uromys validus* Peters & Doria, 1881; *Uromys exilis* Troughton & Le Soeuf, 1929; *Uromys sherrini* Thomas, 1923.

**Revised diagnosis.** Distinguished from other subspecies as follows: i) hindfoot short, 18-22% of head and body length; ii) size large (condylobasal length of adults 63-72 mm); iii) fur colour "rabbity" grey brown or tawny, with underparts yellow or white; iv) feet white with a distinct brown line or block above; v) tail long, with only slight mottling in transition zone; vi) scales arranged in clear rings; frontal region of skull convex; vii) bullae somewhat flattened.

**Discussion.** There is more regional variation within *U. c. caudimaculatus* than in any other subspecies.

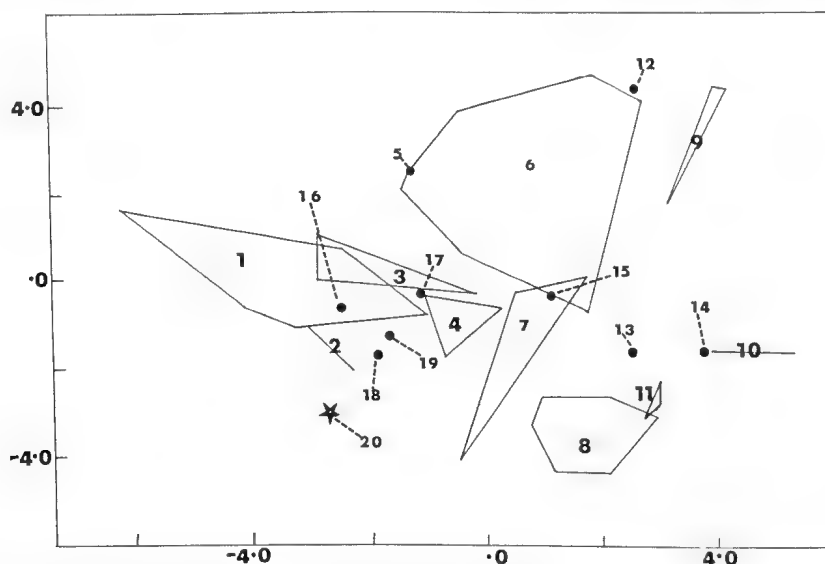


Fig. 4. Discriminant analysis of *U. caudimaculatus* and *U. emmae*. The numbers refer to groupings as follows: 1 = Hagen region, 2 = Mount Karimui, 3 = south-east Papua, 4 = Mount Sisa, 6 = Australian mainland, 7 = Dobodura, 8 = Alkmaar region, 9 = Hinchinbrook Island, 10 = Utakwa River, 11 = Setakwa River. Individual specimens from Yapen (5), Yapsiei (12), Mimika (13), Kaimari (14), Aru Island (15), Telefomin (16), Torricellis (17), Mount Erimbari (18) and Weyland Range (19), fitted in after the calculation of the Functions, are plotted separately, as is the type of *U. emmae* (20). That *U. emmae*, despite being fitted into a pre-calculated analysis, fell outside the dispersion of any *U. caudimaculatus* sample, is highly significant.

Indeed, some of the more distinct regional forms have previously been recognised as subspecies. Individuals from the Aru Islands are smaller than those from elsewhere, and differ morphologically in possessing a distinct dorsal stripe. Those from the trans-Fly plains are again a little smaller than individuals from Australia, possess an indistinct dorsal stripe, have slightly less of the tail white, and have less warm tones in the fur. The Australian sample is, in contrast, remarkably morphologically homogeneous throughout its range. Baverstock *et al.* (1982), however, recognised two chromosome races within it: the southern race is characterised by the possession of two to 12 B chromosomes while the northern race lacks B chromosomes but possesses large blocks of distal C-positive heterochromatin on between 18 and 28 of the 46 chromosomes. Although these two chromosome races seem to be isolated from one another, and no chromosome intermediates are known, we could detect no differences based upon morphology or morphometrics to support the division of the Australian sample into two taxa.

**Distribution.** This subspecies is distributed from north-east Queensland throughout the trans-Fly plains to the Gulf of Papua and the Aru Islands.

*Uromys caudimaculatus papuanus* (Ramsay, 1883)

(not preoccupied by *papuanus*  
von Meyer, 1876, a nomen nudum)

**Synonyms.** *Uromys prolixus* Thomas, 1913; *U. ductor* Thomas, 1913; *U. lamington* Troughton, 1937.

**Type material.** HOLOTYPE. A search of the collections of the Australian and Macleay Museums, Sydney has failed to reveal the existence of this specimen, and we suspect that it has been lost. The type locality is given as Port Moresby or the lower slopes of the Astrolabe Range.

**Revised diagnosis.** Distinguished from other subspecies as follows: i) hindfoot long (21-24% of head and body length); ii) tail averaging longer (110-135% of head and body length); iii) size small (condylobasal length 56-64 mm; head and body length 250-288 mm, see Table 1); iv) feet buffy or brown; v) tail (which is partly white for over half of its length) strongly mottled with brown coalescing spots on its terminal portion, and scales not arranged in such clear rings; vi) underside creamy, smudged in grey; vii) frontals flat; viii) bulla more rounded.

**Discussion.** The Discriminant Analysis (Fig. 4) reveals considerable diversity within this subspecies, but it is difficult to see how it could be split up with two exceptions: i) Yapsiei (two specimens): in the Discriminant Analysis, these specimens resemble

nominotypical *U. c. caudimaculatus*. Univariate analysis reveals that the hindfoot is relatively long (24-25% of head and body length) and the ear markedly so in one of the specimens (44 and 58% of condylobasal length in the two specimens); ii) Mount Karimui (two specimens): these are distinguished from all other samples in the Discriminant Analysis. Univariate analysis reveals a small body size (mean condylobasal length 54.6 mm, head and body 232.5 mm).

We feel that either of these populations may eventually be shown to be distinct, but given the small sample size it would be rash to recognise them as such at present.

**Distribution.** This subspecies is distributed throughout the mainland of Papua New Guinea, except for the trans-Fly plains and the Gulf of Papua, where it is replaced by the nominate race.

*Uromys caudimaculatus multiplicatus* (Jentink, 1907)

**Synonyms.** *Uromys nero* Thomas, 1913; *U. scaphax* Thomas, 1913; ?*U. waigeoensis* Frechkop, 1932.

**Type material.** HOLOTYPE, Leiden Museum (no number), collected at Sentani Lake (2°37'S 141°30'E), Irian Jaya, by the Humboldt Bay Expedition on April 18, 1903.

**Revised diagnosis.** Can be distinguished from other subspecies as follows: i) tail much shorter than head and body; ii) hindfoot short (18-22% of head and body); iii) size small as in *U. c. papuanus* (condylobasal length 57-64 mm; iv) head and body 273-310 mm, see Table 2); v) feet diffusely white above; vi) tail yellow under base with very little (maximum one third) of its length white above, very little or no mottling, tail scales in clear rings; vii) fur tends to be soft, thick, with grizzling due to yellow or red brown tips to hairs; viii) frontals flat; ix) bullae rounded.

**Discussion.** There are differences between the type series of *U. nero* and the juvenile holotype of *U. multiplicatus* and others of this subspecies (those from the Setakwa and Mimika Rivers, Alkmaar and Bivak Island), the former being darker and of larger size. This may represent simple clinal changes with increasing altitude. The holotype of *U. waigeoensis* is described as being very large (head and body length 370 mm), but no other differences from the present subspecies seem apparent.

**Distribution.** This subspecies is distributed throughout mainland Irian Jaya, possibly including Waigeo Island.

**Related taxa of uncertain status.** *Uromys siebersi* Thomas, 1923, is from the Kei Islands. This poorly

known taxon (known from two skins and a single skull) exhibits a mosaic of features that make it difficult to determine whether it should be placed with *U. c. caudimaculatus* or *U. c. papuanus*, or recognised as a distinct subspecies. On the basis of metrical characters it falls near the south-west New Guinean samples. On the basis of its pelage colouration, tail and skull morphology, however, it is very close to Aru Islands *U. c. caudimaculatus*, differing in that it is slightly smaller, the tail is slightly more mottled at the transition, and the frontals are less convex. In these features it resembles *U. c. papuanus*. Thus it is intermediate between these two subspecies.

The single specimen known from Yapen Island (to the north of New Guinea) also somewhat resembles *U. c. caudimaculatus* from the Aru Islands on morphology, and falls within that subspecies on the basis of metrical characters. Because it is represented by only a single specimen, the allocation of the Yapen form must remain uncertain at present.

### *Uromys hadrourus* (Winter, 1984)

**Synonyms.** *Melomys hadrourus* Winter, 1984.

**Type material.** HOLOTYPE, QM J504, adult female, skin and torso in spirit, skull extracted, collected near the summit of Thornton Peak (1,220 m, 16°09'30"S 145°21'45"E) on 16 Nov. 1973 by J. Winter.

**Revised diagnosis.** *Uromys hadrourus* differs from other species of *Uromys* as follows: i) smallest member of the genus; ii) white tail tip that lacks mottled interdigitation with dark proximal area of tail is unique; iii) the postorbital processes reduced; iv) braincase more inflated; v) anterolateral bullar spurs proportionally smaller.

It resembles *U. caudimaculatus* in its palate spine, palate form, rounded braincase, suppressed dentary tubercle, long incisive foramina (25% of palate length), small teeth, tail scales arranged in rings and longer than broad, and its general fawn colour and white feet with a marked brown dorsal line. It differs in its thinner preorbital bar, anteriorly angled lambdoidal suture, flattened interorbital region, less downwardly bowed zygomatic arches, reduced coronoid processes, lesser extent of white on the tail, broad feet, and restriction of white ventrally to the throat and chest.

**Discussion.** *Uromys hadrourus* is thus far known from only five museum specimens, all collected at above 300 m on the Thornton Peak massif, north-eastern Queensland. This massif is isolated from other areas of upland rainforest by the Daintree and Bloomfield Rivers and sclerophyll forest.

Winter (1984) described *U. hadrourus* as a large species of *Melomys*. Although he discussed the possibility that it may represent a small species of

*Uromys*, he discounted this on the basis of its small size, noting nonetheless that the well-developed tail and thickened upper incisors of *U. hadrourus* were striking similarities shared with the species of *Uromys*. Our cladistic analysis shows that *U. hadrourus* shares many derived features with the species of *Uromys*, but none with other mosaic-tailed rats. Such features include the posterior lengthening of the bony palate and the large anterolateral spur of the bulla which are synapomorphic for this genus. Phenetically, *U. hadrourus* is very close to other species of *U. (Uromys)* in skull shape, details of dental morphology and the thickness of the tail.

*Uromys hadrourus* is clearly a member of the *U. caudimaculatus* group of the subgenus *Uromys*, and even shares a few possibly derived features with *U. c. caudimaculatus* which are not seen in *U. c. papuanus* and *U. c. multiplicatus*: notably the white feet with a vaguely expressed brown longitudinal line on the upper surface. Other similarities are, however, plesiomorphic, and on balance it seems likely that it is the sister species to the entire species *U. caudimaculatus*.

### *Uromys anak* Thomas, 1907

**Type material.** HOLOTYPE, BM 7.5.22.2, adult male skin and skull, from Efogi (9°00'S 147°45'E), Owen Stanley Range at not less than 4,000 ft (1200 m). Collected 2 Oct. 1906 by C.A.W. Monckton.

**Revised diagnosis.** *Uromys anak* differs from all species of *U. (Uromys)* except *U. neobritannicus* and *U. boeadii* n.sp. in lacking a white tail tip. It differs from *U. neobritannicus* in its less well-developed postorbital processes, and in having the interorbital region more concave, and in its brown and white mixed underparts. It differs from members of the *U. caudimaculatus* group in that its tail scales are broader than long, its palatal foramina are short (only 14-19% of palate length), the molars are large (more than 20.5% of condylobasal length); in its less bowed zygomatic arches, larger postorbital processes continued downward as swollen ridges, posteriorly extended nasals, flatter braincase, more flattened auditory bullae, less anteriorly protruding nasals and deeper rostrum.

**Notes.** The Discriminant Analysis (Fig. 5) shows an almost clean division between samples from Mount Simpson and the Mount Hagen region, and these are here recognised as distinct subspecies. Two specimens from Telefomin and one from Mount Elimbari also stand well apart from the rest. Unfortunately no specimen from the Huon Peninsula is complete enough to enter into the analysis. As a high-altitude species, it is possible that a number of distinctive and semi-isolated subspecies will eventually be discernible.

*Uromys anak anak* Thomas, 1907

**Revised diagnosis.** Distinguished from other subspecies as follows: i) colour less dark than *U. a. rothschildi*; ii) body smaller; iii) tail longer; iv) hindfoot shorter.

**Notes.** The nominotypical subspecies is widely distributed along the New Guinean Central Cordillera above about 1000 m, from Mount Dayman in the Owen Stanleys in the east to the upper Bubu River region in the west.

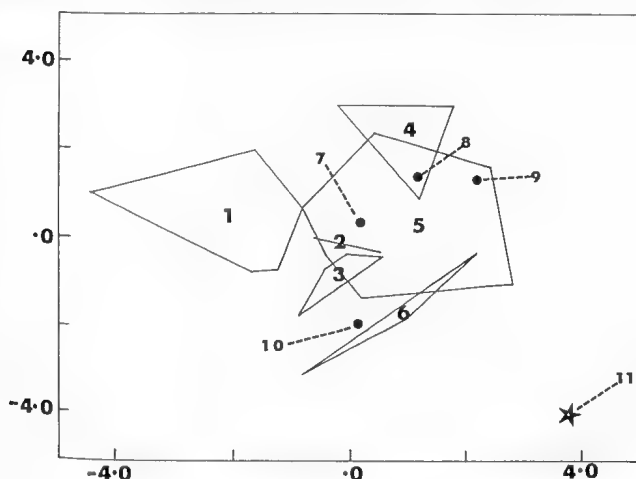
*Uromys anak albiventer* n.subsp.

Figs 6,7, Table 1

**Type material.** HOLOTYPE, CSIRO Division of Wildlife and Ecology, Canberra no. CM.8532, adult male, skin and skull, from Uinba, Kubor Range, Papua New Guinea. Collected on 22 June 1963.

**Diagnosis.** Distinguished from other subspecies as follows: i) coat more brown-toned; ii) venter much more broadly white, from throat to groin; iii) teeth smaller.

**Discussion.** From Upper Bubu River region, as far west apparently as the Weyland Range. Of two specimens from Saiko, Bubu River, in the BM, one is



**Fig. 5.** Discriminant analysis of *Uromys anak* and *U. boeadii*. The numbers refer to groupings as follows: 1 = south-eastern peninsula, mainland Papua New Guinea (*U. a. anak*), 2 = Mount Erimbari, 3 = Habbema region, 4 = Bubu River (intermediate sample), 5 = Hagen region (*U. a. albiventer*), 6 = Telefomin. Individual specimens from Teri, Rawlinson Range (*U. a. rothschildi*), Okapa (7), Rawlinson Range (8), Tari (9) and Weyland Range (10) are plotted separately, as is the type of *U. boeadii* (11, which, until this analysis, we had considered a probable subspecies of *U. anak*). Note that *U. boeadii*, despite being fitted into a pre-calculated analysis, falls even farther beyond the dispersion of *U. anak* than does the type of *U. emmae* from *U. caudimaculatus*.

entirely typical of this subspecies, while the other has the ventral white restricted as in nominotypical *anak*. In the Discriminant Analysis, both specimens fall with the present subspecies.

To this subspecies belong a series of seven specimens (6 skins with skulls, 1 skull only) in the British Museum (Natural History), from the Kratke Mountains (Buntibasa, Kuraka, Apimuri) and east of the Hagen Range (Degabaga, Menebe). Certain other specimens may yet turn out to represent distinctive subspecies. These are from Lamende Range, near Mount Giluwe, and from Telefomin and Mount Elimbari. The Mount Giluwe specimen (BM 53.370) has the largest skull seen by us; the molars are however very small (molar row length 12.2 mm), and the tail is short (106% of head and body). The dorsal colouration is dark, and the venter has no white, being all grey; in these features it resembles *U. a. rothschildi*. The two Telefomin specimens are very small in size, but have large teeth. Five specimens from Mount Elimbari are also rather small in size, but have small teeth, and relatively long tails and ears. Only further material will allow us confidently to determine the nature of these variant populations.

*Uromys anak rothschildi* Thomas, 1912

**Type material.** HOLOTYPE, BM 12.1.31.2, adult female skin and skull, collected by C. Keyser in the Rawlinson Mountains (6°43'S 147°06'E), Huon Peninsula, Papua New Guinea.

**Revised diagnosis.** Differs from other subspecies in the following combination of features: i) very dark, brown-black dorsum, with a paler (but not white) venter; ii) very large size with large teeth; iii) relatively short tail (100-113% of head and body length); iv) short hindfoot (19-21% of head and body length).

**Discussion.** This poorly known subspecies inhabits the isolated Huon Peninsula of northern New Guinea.

*Uromys neobritannicus* Tate & Archbold, 1935

**Type material.** HOLOTYPE, AMNH 99881, skull only of an adult male collected on New Britain, Bismarck Archipelago by J.W. Eyerdam.

**Revised diagnosis.** *Uromys (U.) neobritannicus* differs from all other species of *Uromys* as follows: i) hypertrophy of the postorbital processes; ii) uniformly black tail (otherwise in subgenus only in *U. anak* and *U. boeadii* n.sp., from which it also differs by much larger postorbital processes, square posterior ends of nasals which do not extend as far posteriorly, reddish body colour with deep yellow venter, and more numerous tail scales [16 per cm]); iii) unlike *U. anak*, but like

*U. boeadii* n.sp., there are no swollen vertical ridges below postorbital processes, despite the large size of the processes; iv) one of the largest species, equal in size to *U. anak*.

**Discussion.** *Uromys neobritannicus* is thus far known only from six individuals, all collected on New Britain. The holotype is a skull only, localised only as far as New Britain. The second specimen (AMNH 119467) is a male skin and skull that was collected at

Talasea (on the Mundo Willaumez Peninsula) by Fr Schumm (Tate, 1951). The third known specimen is held in the Museum of Victoria. It is a subadult female (no. 6890) collected on the Mundo Willaumez Peninsula on the north coast of New Britain by Clive Champion. Three additional specimens (one in spirits (AM M20690), two skins and skulls (AM M20689, AM M21118)), from the Fulleborn area East New Britain, are in the Australian Museum.

Recent work on New Ireland by one of us (TFF) failed

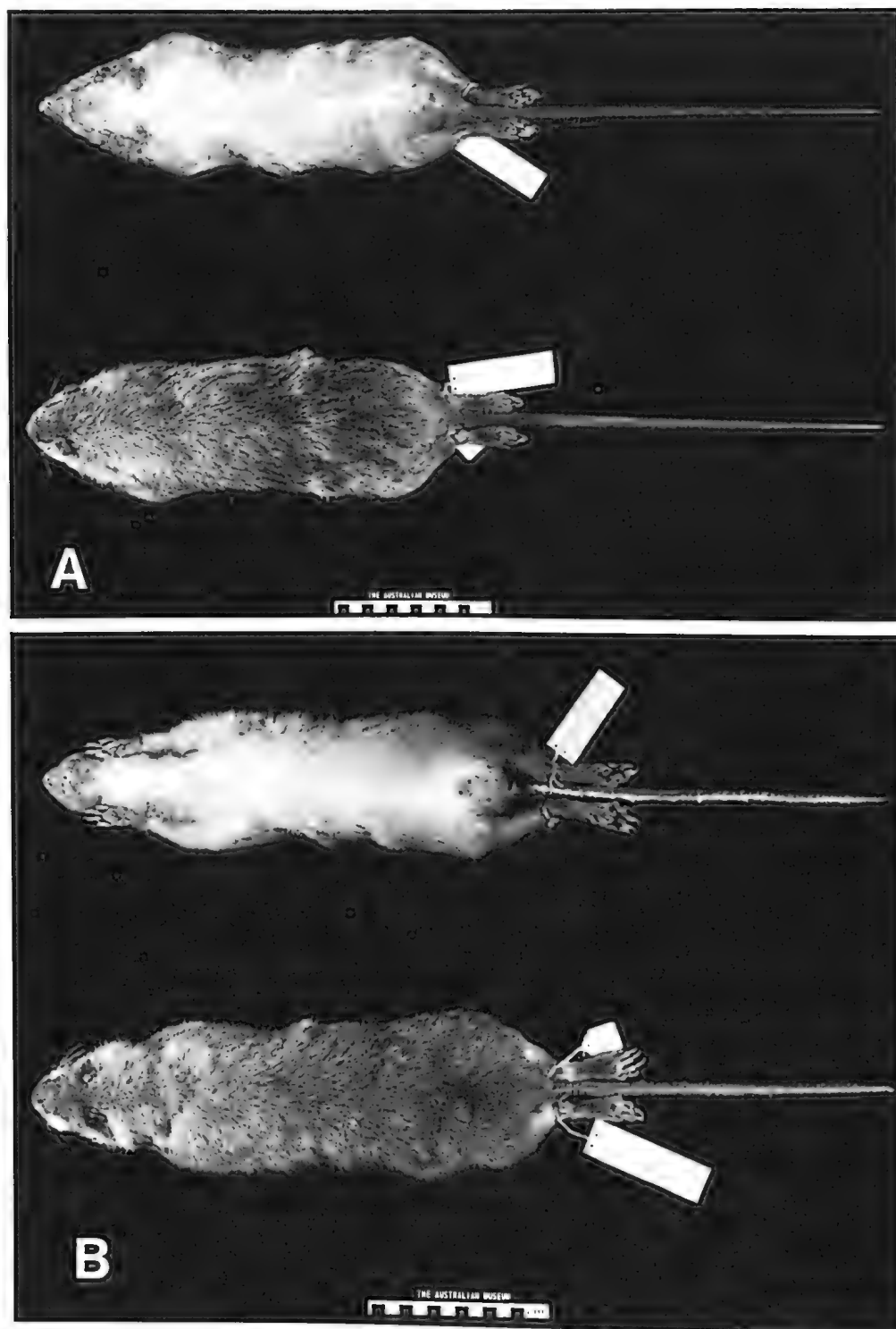


Fig. 6. Comparison of skins of A, *Uromys anak anak* (CSIRO 12337) and B, *U. a. albiventer* (CSIRO 8532).



to find it there despite extensive fieldwork and analysis of extensive archaeological material (Flannery & White, 1991), and it seems unlikely that the species inhabits any of the smaller islands off New Britain.

**Relationships.** *Uromys neobritannicus* is clearly the sister species to *U. anak*, from which it differs in a few skull characters and in colour; of these it is likely that the condition seen in the present species is the plesiomorphic one, with the exception of the striking postorbital processes (a gross enlargement of the small tubercles of *U. anak*), and the more numerous tail scales.

*Uromys boeadii* n.sp.

Figs 8, 9, Table 2

**Type material.** HOLOTYPE, AMNH 222242, young adult male skin and skull, collected by Philip Temple on 22 March 1963, 25 km north-east of Biak, Pulau Biak, Geelvinck Bay, Irian Jaya, Indonesia.

**Etymology.** For Bp. Boeadi, Indonesia's most eminent mammalian taxonomist, and one of that country's leading biologists.

**Diagnosis.** This new species is phenetically closest to the *U. anak/U. neobritannicus* group, agreeing with the members of this group in its uniformly black tail,

the deep rostrum, the tendency towards development of distinct postorbital processes, and the posteriorly extended nasal bones. It differs from them in the following ways: i) size much smaller; ii) postorbital processes poorly developed; iii) posterior ends of nasal bones only just reaching level of anterior orbital margins; iv) tail scales longer than broad, and arranged in clear rings. It differs additionally from *U. anak* as follows: i) lack of prominent inflation of frontotemporal sutures; ii) flat interorbital area. It differs from *U. neobritannicus* as follows: i) less tail scales (7-9 per cm of length); ii) deep black-brown colour with sharply marked median pectoral streak.

**Description.** The holotype (and only known) skin and skull are in good condition. The overall colour is deep blackish brown, tending to be darker on the foreparts and with a lighter sheen on the hindparts. The pelage consists largely of long, dark guard hairs, somewhat paler towards the base, with a few light-coloured guard hairs and crimped grey-white underhairs mixed in. The venter is sparsely furred, with the lighter skin tone showing through; the ventral hairs are mostly brown, but there is a sharply marked creamy-white streak, 92 mm long, in the midline of the chest, along the approximate extent of the sternum, beginning as a thin streak at about the level of the axillae, broadening suddenly 22 mm further back, and narrowing gradually behind (Fig. 8). Hands and feet are lighter brown owing to the sparseness

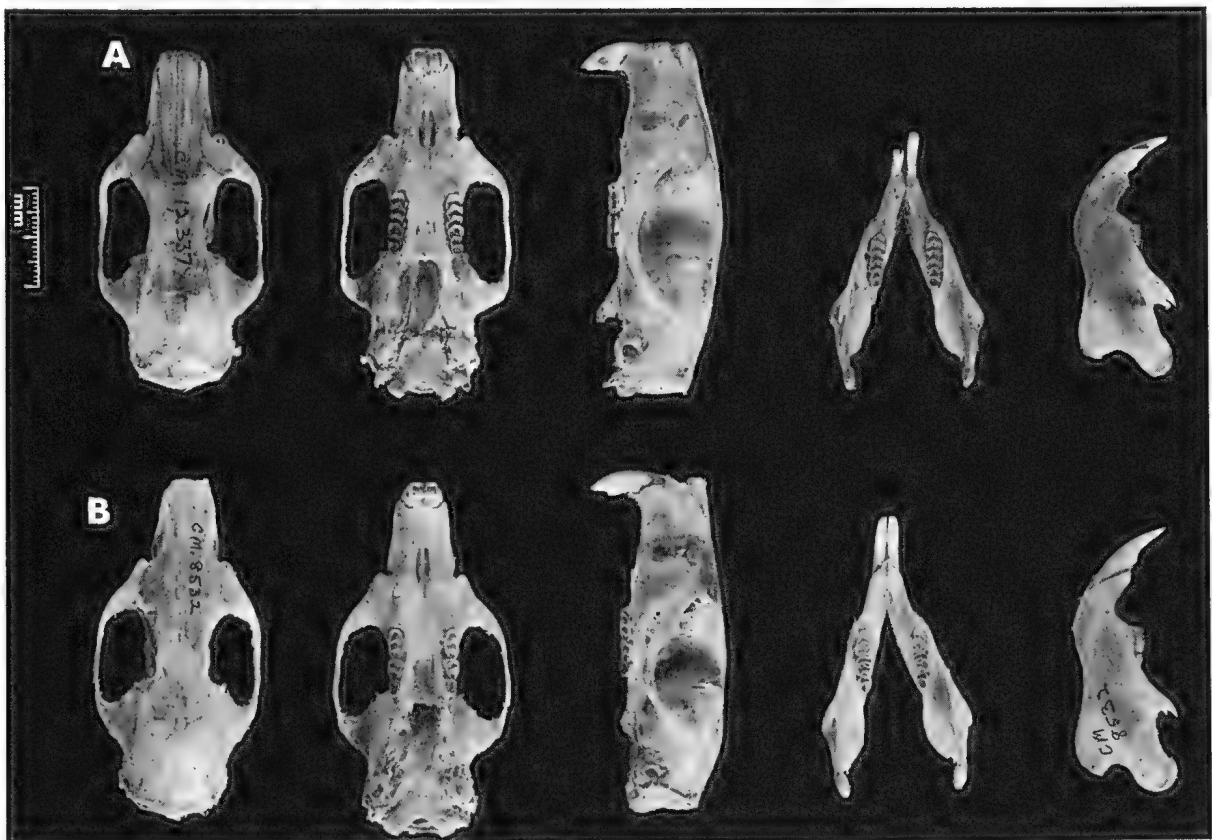


Fig. 7. Comparison of skulls of A, *U. a. anak* (CSIRO 12337) and B, *U. a. albiventer* (CSIRO 8532).



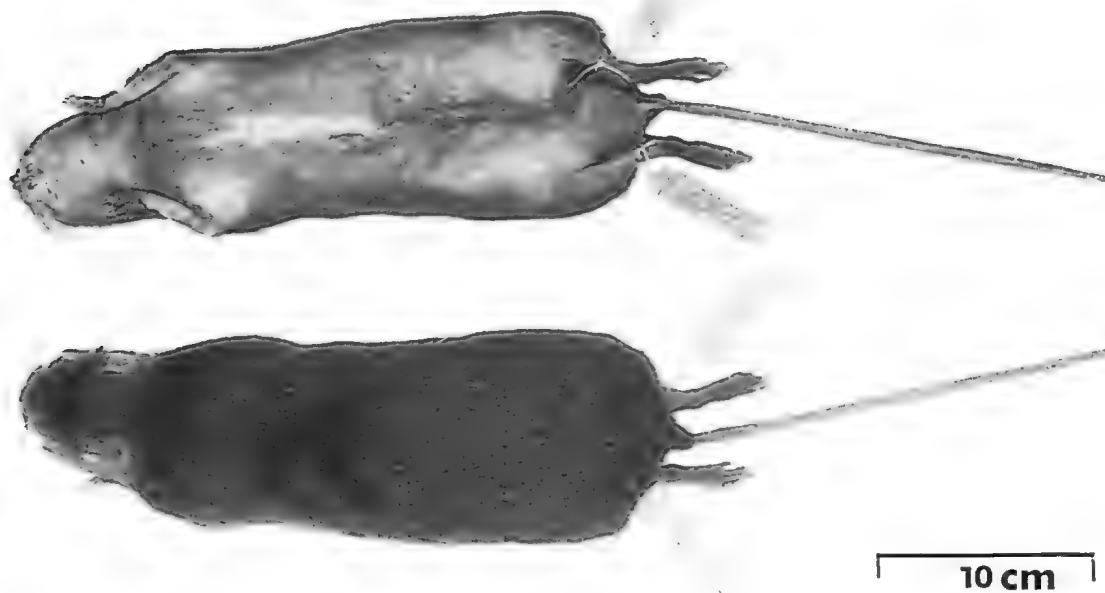


Fig. 8. Study skin of holotype of *U. boeadii* (AMNH 222242).

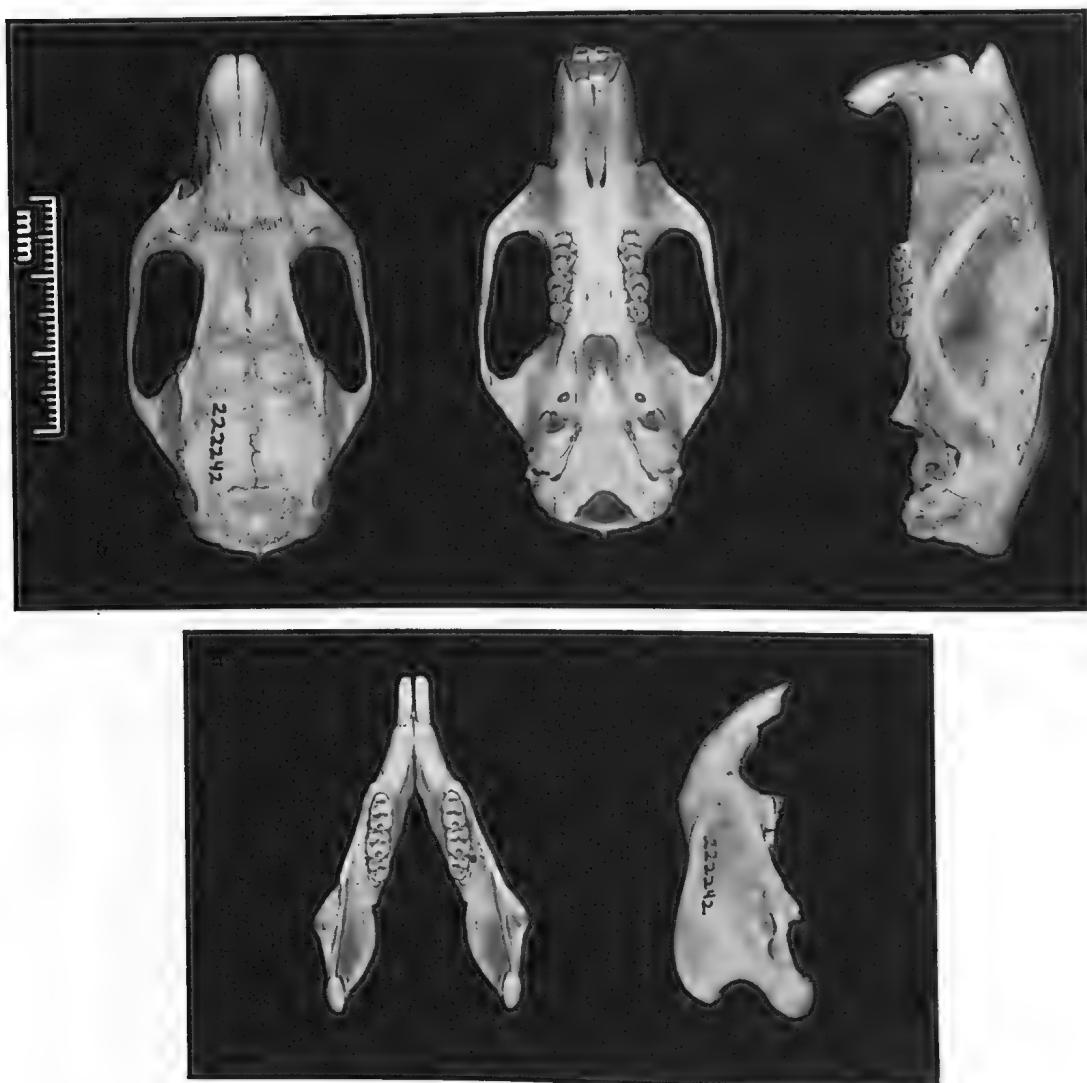


Fig. 9. Skull and dentary of holotype of *Uromys boeadii* (AMNH 222242).

of the hair covering; vibrissae are long and black. The tail scales are somewhat longer than broad, flattened, and arranged in rings.

The skull is deep, especially the rostrum, as in *U. anak* and *U. neobritannicus*, but unlike these the nasals are relatively short, and the postorbital processes are only slightly developed. The parietal crests are well developed, extending forward to form clear supraorbital ridges. The premaxilla extends back on either side nearly to the zygomatic plate. The zygomatic arches sweep downward to just above the level of the posterior molar alveoli, then curve up again to their posterior roots above the external auditory meati. The incisive foramina are slit-like. The palate ends squarely somewhat posterior to the third molars; the mesopterygoid fossa is broad, parallel-sided. The bullae are small (Fig. 9).

**Discussion.** Consideration must always be given to the problem of what level of taxonomic recognition should be awarded to entirely allopatric taxa. In the present case, the evidence is overwhelming that, cladistically, *U. boeadii* is the plesiomorphic sister-taxon to the *U. anak/neobritannicus* clade, or to all *Uromys* (*Uromys*); consequently, if these are to be maintained as separate species, *U. boeadii* must be given species rank as well.

While most of its features are evidently plesiomorphic, the restriction of the white zone to a pectoral streak and the complete absence of any white in the inguinal region would appear to be autapomorphic states of this new species, perhaps its only ones.

### *Uromys emmae* n.sp.

Figs 10-12, Table 2

**Type material.** HOLOTYPE, AM M7200, adult female skin and skull. Collected by Col. C.B. Phillips of the USA Typhus Commission on Owi Island (1°16'E 136°13'S), Schouten Group, Geelvinck Bay, Irian Jaya, Indonesia. The specimen was registered on 1 July 1946, and was probably collected during 1944-1945.

**Etymology.** For the junior author's daughter, Emma.

**Diagnosis.** *Uromys emmae* can be distinguished from all other species of *Uromys* except *U. caudimaculatus* in having a mottled section of the tail, where the light tip contacts the darker proximal part. It differs from *U. caudimaculatus* in the following ways: i) hindfoot shorter, broader; ii) body fur shorter, coarser; iii) white mottling on tail restricted to distal third, where it is limited in extent, and terminal 1 cm brown (in other species white tail section much more extensive); iv) rostrum relatively and absolutely shorter; v) preorbital foramen hidden behind zygomatic plates (most of it visible in other species); vi) frontals not inflated, supraorbital ridging better developed, incisive foramina shorter (only 18.4% of palate length); vii) molars relatively larger (21% of condylobasal length); viii) posterior ends of nasals extend further posteriorly; preorbital bar thinner; ix) zygomatic arches less swung downwards.

**Description.** The holotype skin is in good condition

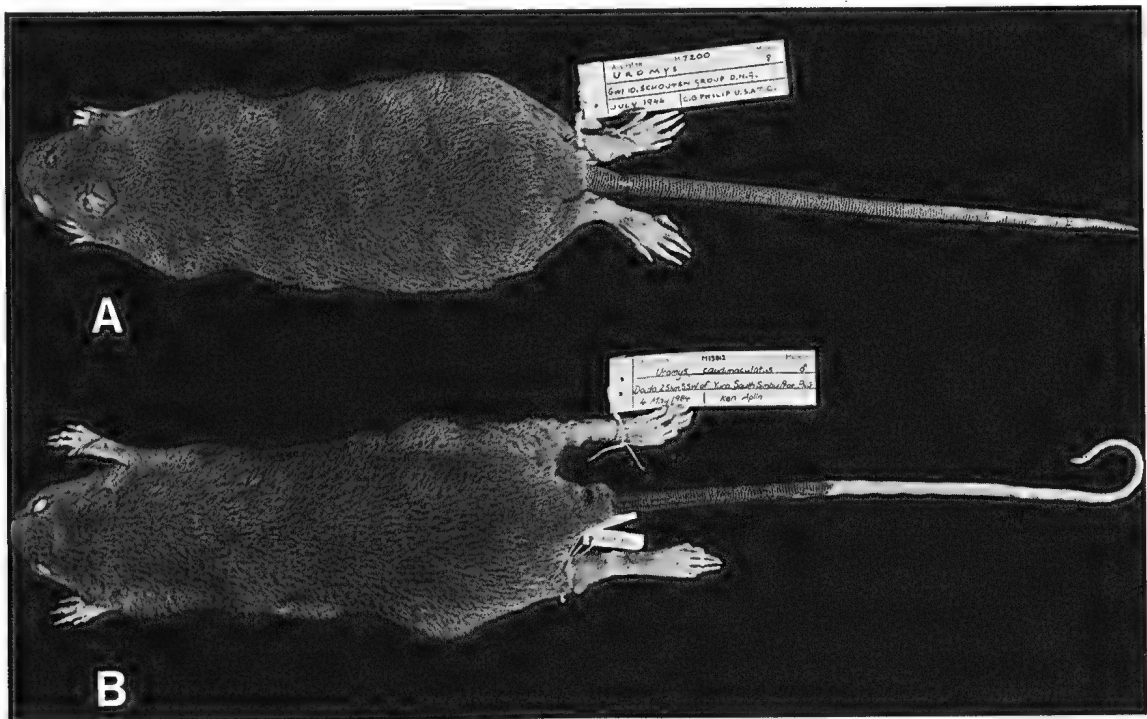


Fig. 10. Study skins in dorsal view of A, holotype of *U. emmae* and B, *U. caudimaculatus papuanus* Mount Karimui area, AM M13812.

except that the right pinna is missing, the interorbital region has been damaged by a rat trap, and part of the venter is soiled (Figs 10, 11). The guard hairs of the dorsum are tipped with Clove Brown, while the fur is tipped with Straw. The bases of all of the dorsal fur is Dull Grey. The overall effect of the dorsal colouration is somewhat less rufescent than most *U. caudimaculatus*. A ring of slightly darker hairs surrounds the eyes. The hindquarters are Prout's Brown, with the tipping of the hairs being less conspicuous than anteriorly, and the guard hairs reduced in number. The venter is sparsely furred, the hairs being dirty white from the anus to the chin. The vibrissae are black. The dorsal surface of the feet are clothed in fine, pure white hairs except on the metatarsum proximal to digits 2-3, where some light brown hairs are present. The feet are unusually broad and short with smooth plantar pads (Fig. 13). They are only 50.5 mm long (su) but 13.5 mm wide at the base of the fifth metatarsal. Tate (1951) gives measurements of the hindfoot for the holotypes of *U. nero*, *U. aruensis*, *U. scaphax*, *U. prolixus*, *U. ductor*, *U. seibersi* and *U. sherrini*. The length-width ratio for this sample is as follows:  $X = 0.18$ , range = 0.15-0.19, s.d. = 0.014 ( $n=8$ ). Measurements of *U. caudimaculatus* held in the Australian Museum conform closely to Tate's sample. This compares with a ratio of 0.27 for *U. emmae*. It is highly unlikely that preparation method could have affected these measurements, both because the measurements of *U. emmae* taken in the field and from the study skins are similar, and because the proportions of the foot are altered little by preparation relative to other body parts. The mammary formula is  $0 + 2 = 4$  and, to judge from the size of the nipples, the animal

was lactating when caught. Over the proximal 120 mm of the tail the tail scales are raised to a conical point, the tail resembling a file. The scales become progressively more flattened distally, forming irregular tesserae near the tip. Limited white mottling is present over the distal one third of the tail, but white encircles the tail only in two narrow places. The terminal 1 cm is dark. There is a single hair per tail scale, visible only under magnification, which is one half to one third of a scale in length.

The skull is cracked through just anterior to the parietal-frontal suture; damage typically inflicted by the bar of a rat trap. The teeth are moderately worn and several have been glued into their sockets. The rostrum is short and narrow relative to that of other species of *Uromys*. The premaxillary/maxillary suture is positioned just anterior to the zygomatic plate, the entire masseteric foramen being hidden behind the zygomatic plate when the skull is viewed from the side (Fig. 12). The incisive foramina are remarkably short, narrow and parallel sided. The frontals in the interorbital region are slightly dished, and weak supraorbital ridging developed. The parietal crests are weakly developed and are subparallel. The palate and upper molars are essentially similar in morphology to those of *Uromys caudimaculatus*. The mesopterygoid fossa is narrow relative to *U. caudimaculatus*. The pterygoids are damaged. The bullae are small and resemble those of *U. caudimaculatus*. Except in their smaller size, the dentary and lower dentition do not differ from those of *U. caudimaculatus*.

**Discussion.** As in the case of *U. boeadii*, careful consideration has been given as to whether the taxon

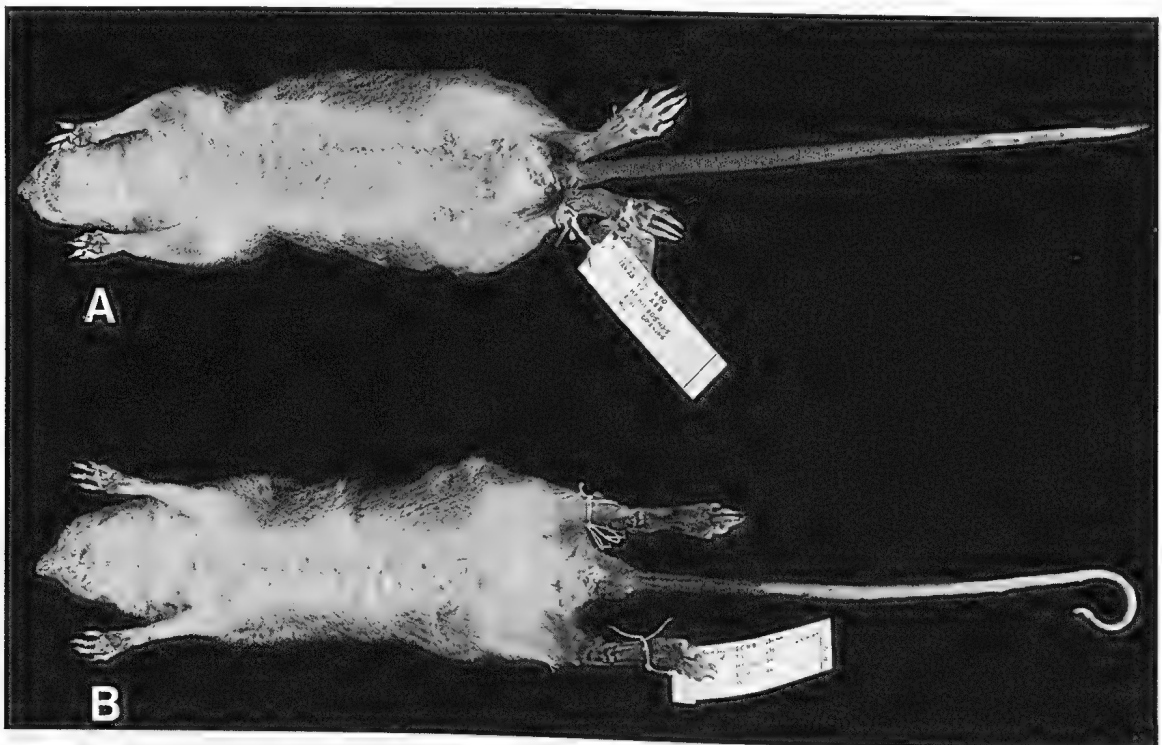


Fig. 11. Study skins in ventral views of A, holotype of *U. emmae* and B, *U. caudimaculatus papuanus* Mount Karimui area, AM M13812.

*U. emmae* should be recognised as a new species, or as a subspecies of *U. caudimaculatus*, always a difficult question to resolve when dealing with insular taxa for which the criterion of reproductive isolation is immaterial and sample size is small. We decided that *U. emmae* should be described as a full species for the following reasons. 1) It differs from *Uromys caudimaculatus* in a number of features that are not observed to vary among the previously recognised subspecies of the latter taxa. These features include the short, very broad hindfoot; short rostrum; recession of the masseteric foramen behind the zygomatic plate, and short, sparse coat. 2) Some of the distinguishing features of *U. emmae* argue for a quite different ecological niche from that of *U. caudimaculatus*; in particular the short, broad hindfoot and the shortened rostrum denote considerable specialisation. Short, broad feet and a foreshortened snout are commonly seen in Melanesian murid taxa that are highly arboreal (eg, the species of *Pogonomys*, *Chiruromys* and *Melomys rufescens*), while

elongated hindfeet and a long skull are typical of terrestrial taxa (eg, *Xenuromys barbatus*, *Melomys lorentzi*). The combination of a short, broad hindfoot and short snout may well indicate that *U. emmae* is more arboreal than *U. caudimaculatus*. (3) It shares plesiomorphic features with *U. hadrourus*: nasofrontal suture well posterior to the level of the preorbital foramen; thin preorbital bar; uninflated interorbital profile; weaker zygomatic arches; and broader feet, recalling *U. (Cyromys)*. It retains other apparently plesiomorphic states not seen in either *U. hadrourus* or *U. caudimaculatus*, including relatively small ears (39% of condylobasal length), short incisive foramina, and relatively large teeth. In all of these features it resembles *U. anak* and *U. neobritannicus*.

In addition to *U. boeadii* and *U. emmae*, the terrestrial mammalian fauna of the Geelvinck Bay islands, including Owi Island (Palau Awai) and Biak Island (P. Biak) includes a number of endemic taxa. A highly distinctive and diminutive race of spiny bandicoot (*Echymipera kalubu philipi*) has previously

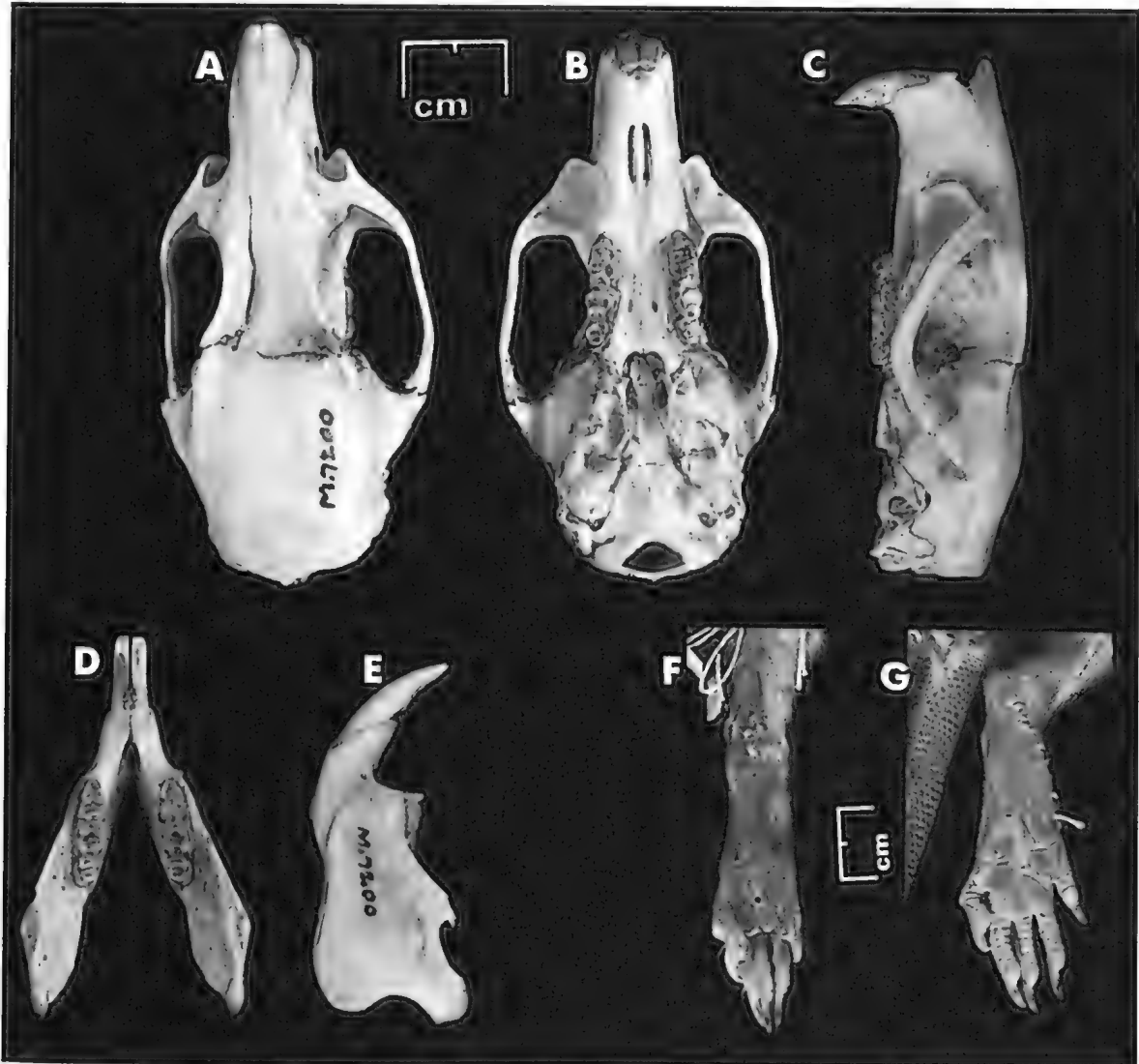


Fig. 12. Holotype cranium of *U. emmae* in: A – occlusal, B – dorsal and C – lateral views, and dentary in D – occlusal, and E – lateral views. F – pes of *U. caudimaculatus* AM M13812, Mount Karimui, and G – holotype of *U. emmae*.

been named (Troughton, 1945). Troughton (1945) also described *Petaurus kohlsi* from Owi, but this is a junior synonym of *Petaurus breviceps biacensis* Ulmer, 1940, a taxon so distinctive that it may represent a distinct species unique to Owi and Biak Islands. Two *Rattus* species, *R. jobiensis* and *R. exulans*, are also found on Owi. The former is known only from Owi, Biak and nearby Japan Islands, while the latter species is a widespread Human commensal. Thus the degree of endemism among the mammals of the Owi-Biak Island group (which were connected during the late Pleistocene), is very high. The occurrence of *R. jobiensis* on Yapen as well as Owi-Biak is intriguing, especially as it is *Uromys caudimaculatus* (as documented by BM 46.642, which is a large individual of cbl = 63.0, bzw = 32) is present on Japan, the two endemic Geelvinck *Uromys* species not being known from there. It is possible that the occurrence of *R. jobiensis* on Yapen could be due to accidental human transportation, as it is the only mammal taxon with such a distribution, and other species of *Rattus* have been widely distributed by this means in other parts of the Pacific.

### Discussion

**Interrelationships.** Table 3 lists the characters used by us in constructing a cladogram for *Uromys*, and Table 4 is a list of the character states for each species. Figure 13 shows the one cladogram produced by Hennig86 using the coding given in Table 4, except

that characters 12, 15, 24, 25, 35, 43, 44 and 48 are dropped as only one taxon in each case shows the derived condition. There is a basic split between the two subgenera. Within *U. (Cyromys)*, *U. porculus* is the sister species to *U. rex* and *imperator*. Within *U. (Uromys)*, *U. boeadii* is sister to all other species; next there is a split between *U. anak* and *neobritannicus* on the one hand, and the *caudimaculatus* group on the other; within the latter, *U. caudimaculatus* and *hadrourus* are closer than either is to *U. emmae*.

Node 15, defining subgenus *Cyromys*, is defined by the derived states of characters 5, 7, 11, 13, 20, 22, 23, 26, 27, 32 and 38. The condition of character 42 is equivocal. At node 13, the characters showing derived states in common between *U. rex* and *imperator* are numbers 2 and 9.

Node 16, defining subgenus *Uromys*, is defined by the derived states of characters 1, 3, 18, 38, 40, 41 and 45; the condition of characters 11, 21 and 29 is equivocal. At node 14, all of *U. (Uromys)* except *U. boeadii* have the derived states for characters 4, 6, 8 and 19; characters 21 and 29 are equivocal, and character 11 shows a possible reversal. At node 11, *U. anak* and *U. neobritannicus* share the derived states of characters 10, 21, 32 and 33, and characters 21 and 29 have possible reversals.

At Node 12, *U. emmae*, *U. caudimaculatus* and *U. hadrourus* share derived states for characters 1, 3, 10, 16, 29, 31, 32, 37 and 47. Finally at node 10 *U. caudimaculatus* and *U. hadrourus* share derived conditions for states 18, 36 and 39.

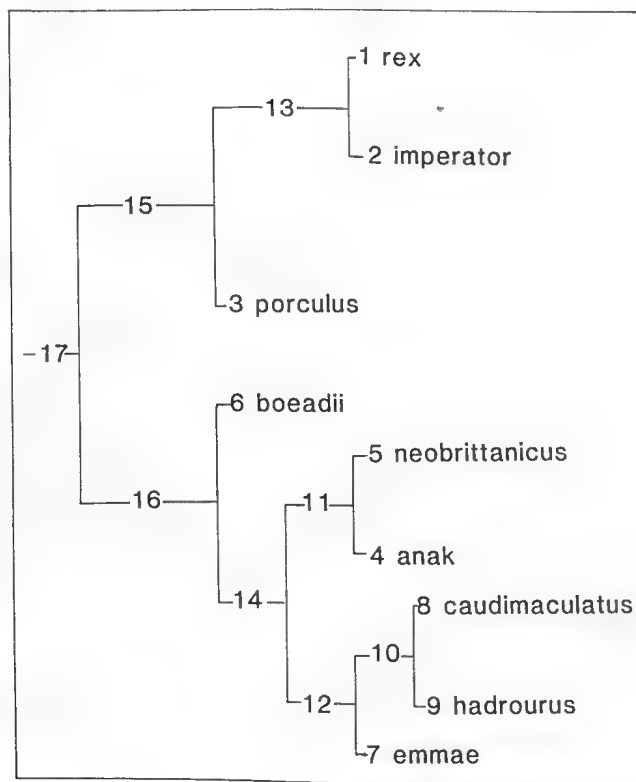
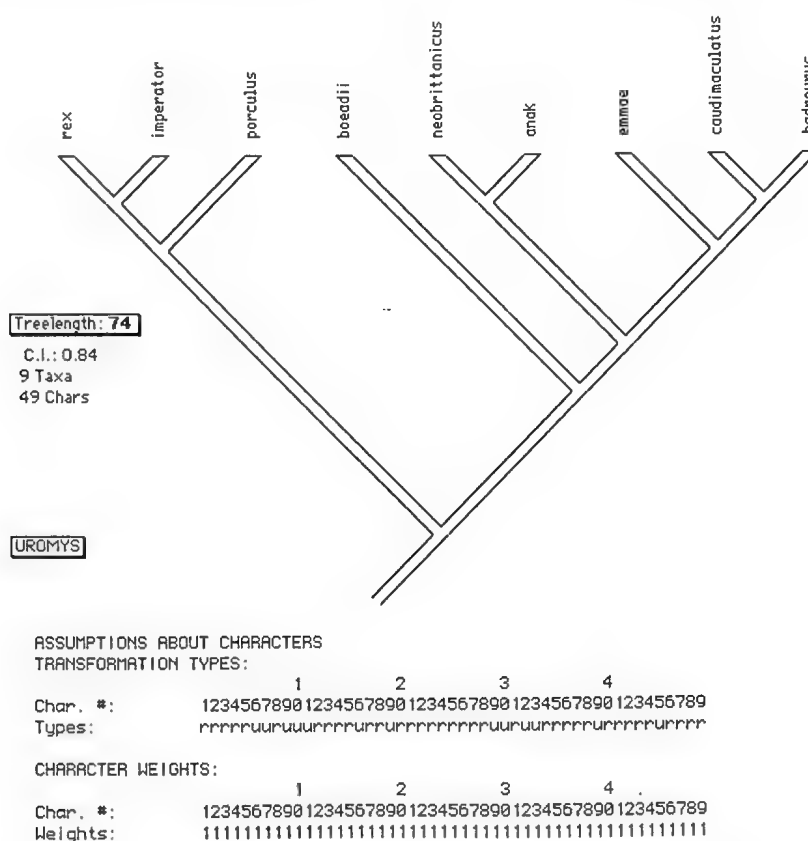


Fig. 13. Most parsimonious cladogram for the genus *Uromys* produced by Hennig86.

The species of *Uromys* (*Cyromys*) however do possess some synapomorphies that unite them as a group; characters 8, 14, 21, 23, 26, 27 and 28. In addition, the morphology of the tail is highly distinctive, although in the binary coding used here it appears similar to that of the *U. anakneobritannicus* group. The tail scales are soft, and have a small hard prominence in the centre of each scale region. All other species of *Uromys* have flat, hard scales arranged in a

Within *Uromys* (*Uromys*), interrelationships are a little clearer (*U. boeadii* again excepted for the moment). We recognise two distinct groups. The first group represented in our cladogram is the clade containing *U. anak* and *U. neobritannicus*. Despite the considerable phenetic similarities between these taxa, very few possible synapomorphies could be found that may link them. The most obvious is the hypertrophy of the postorbital processes; in both species they are larger than in any other *Uromys* (although because they are not wholly absent in *U. caudimaculatus* and *U. emmae* the binary coding does not show this fully), but in *U. neobritannicus* they are greatly developed. The form of the tail scales is unique. Rostral deepening, and the posterior position of the posterior nasal ends, are certainly further synapomorphies, though both are convergent on *U. rex*.



**Fig. 14.** Four equally parsimonious cladograms of genus *Uromys*: (a) *U. boeadii* is sister species to other members of *U.* (*Uromys*).



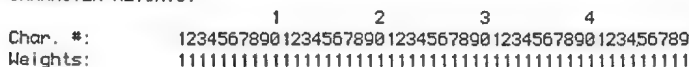




**Zoogeography.** The species of *Uromys* are dispersed over a wider area than almost any other genus of Melanesian murid. Two species are found in north-eastern Queensland, two on the island of New Guinea, one each on P. Owi, P. Biak and New Britain, and three on Guadalcanal in the Solomon Islands (Fig. 1). The three species restricted to Guadalcanal are in many respects the most plesiomorphic, and present the most enigmatic zoogeographic problem. Guadalcanal is close to the middle of the Solomon Islands chain. During times of lowered sea level as little as 1 km of open water separated it from the southern tip of Greater Bukida, a landmass that incorporated all the eastern islands of the Solomons from Buka to Nggela (Diamond, 1974). All of the Greater Bukidan fragments, as well as Ugi Island to the south of Guadalcanal, lack species of *Uromys* but are inhabited by various species of the endemic Solomon Islands murid genus *Solomys*, which differ so widely from the species of *Uromys* that they are probably only distantly related to them. The presence of three species of *Uromys* on an island in the middle of an island chain otherwise inhabited by the species of *Solomys* is intriguing. It may be that fortuitous rafting of an ancestral *U. (Cyromys)*, perhaps

Further difficulties in interpreting zoogeography present themselves when one considers the species of *Uromys* that inhabits the Bismarck Archipelago. A single species, *U. neobritannicus*, is present on New Britain – a close relative of the mainland New Guinean *U. anak*. Analysis of a large amount of archaeological material, and a detailed mammal survey (Flannery & White, 1991) make it clear that *Uromys* is totally absent from New Ireland, and has not been present there over the last 30,000 years. It therefore seems highly unlikely that New Ireland acted as a stepping stone for the species of *Uromys* between New Guinea and the Solomons. Indeed, that *U. neobritannicus* has failed to cross the narrow (30 km at present) strait into New Ireland, where there are no similar-sized murids, but abundant apparently suitable habitat, is eloquent of the difficulties the species of *Uromys* face in dispersing over water barriers.

*Uromys neobritannicus* presents other problems for



**Fig. 14 (cont'd).** Four equally parsimonious cladograms of genus *Uromys*: (c) *U. boeadii* is sister species to all other species of the genus.



Thornton Peak rat, described as *Melomys hadrourus*, is transferred to *Uromys*; it is the sister species of *U. caudimaculatus*. Three subspecies are recognised within each of the two widespread species, *U. caudimaculatus* and *U. anak*.

**ACKNOWLEDGMENTS.** We would like to thank the executors of the Scott Estate, for without their help, collection of material that made this study possible could not have taken place. We would like to thank the following curators for their kindness in facilitating access to specimens in their charge (and, in some cases, loaning them to us): Joan Dixon (Museum of Victoria, Melbourne); John Edwards Hill and Paula Jenkins (Natural History Museum, London); Chris Smeenk (Rijksmuseum van Natuurlijke Historie, Leiden); John Calaby (CSIRO Division of Wildlife and Ecology, Canberra); Steve Van Dyck and Ralph Molnar (Queensland Museum, Brisbane); and Carla Kishinami (Bernice P. Bishop Museum, Honolulu). We would particularly like to thank Guy Musser, Ken Aplin and Allen Greer for helpful comments and suggestions.

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## APPENDIX

Table 1. Localities and selected measurements for *Uromys anak* and *U. caudimaculatus* examined during our study.

	Condylobasal			Molar Row			Head + Body Length			Tail:H+B
	Mean	s.d.	n	Mean	s.d.	n	Mean	s.d.	n	Range
<i>U. caudimaculatus</i>										
<i>U.c. caudimaculatus</i> :										
Cape York Peninsula	68.3	2.36	5	12.5	0.38	11	334	25.9	4	99-123
Cooktown/Townsville	69.9	1.40	6	11.5	0.65	15	282	19.7	7	101-128
Atherton Tablelands	67.4	2.23	4	12.0	0.58	17	296	20.0	4	106-130
Hinchinbrook Island	67.2	2.23	4	12.0	0.41	4	281	13.3	5	110-124
Kaimare (young adult)	63.4	-	1	12.4	-	1	268	-	1	93
Katau (type)	-	-	-	11.0	-	1	-	-	-	100
Western Division	62.4	2.19	6	11.3	0.74	6	278	7.5	6	95-111
<i>U.c. papuanus</i> and cf. <i>papuanus</i> :										
Smallest size (Mount Hagen)	59.6	1.74	11	11.2	0.27	17	264	10.4	11	105-132
Largest size (Telefomin)	60.2	1.88	5	11.6	0.30	6	269	12.7	6	105-132
Mount Karimui	54.6	-	2	11.4	-	2	232.5	-	2	120-125
Yapsiei	60.1	-	1	11.6	-	1	230	-	1	112-135
Torricelli Mountains	64.5	-	1	11.6	-	1	272	-	1	122
Dobodura/Mount Lamington	59.9	2.13	5	11.8	0.40	5	258	9.6	5	100-112
<i>U.c. multiplicatus</i> and cf. <i>multiplicatus</i> :										
Alkmaar/Mimika/Setakwa	59.6	1.78	8	11.1	0.37	13	295	15.9	8	79-88
Utakwa	64.1	-	2	11.9	0.36	3	283	-	2	83-84
Weyland Range	63.7	-	1	12.3	-	2	273	-	2	105-114
Waigeu (Frechkop)	-	-	-	14(?)	-	1	370	-	1	88
<i>U.c. subsp.</i>										
Yapen	63.0	-	1	12.0	-	1	294	-	1	109
<i>U.c. subsp.</i> (described as <i>siebersi</i> and <i>aruensis</i> ):										
Great Kai Island	59.5	-	1	13.3	-	1	280	-	1	84
Aru Island	63.2	-	1	11.7	0.52	3	275	-	2	104
<i>U. anak</i>										
<i>U.a. anak</i>	69.1	0.96	6	13.5	0.24	7	319	8.4	6	119-130
<i>U.a. albiventer</i> :										
Kubor Range	70.6	1.94	5	12.5	0.40	8	329	7.2	5	106-129
Erimbari	67.5	2.39	4	12.8	0.51	5	313.5	-	2	116-123
Telefomin	67.0	-	2	13.3	-	2	309	-	2	100-113
Mount Giluwe	73.3	-	1	12.2	-	1	340	-	1	106
<i>U.a. rothschildi</i>	70.8	-	1	13.0	0.44	3	355	-	1	100

Table 2. Measurements of type specimens of *Uromys emmae* and *U. boeadii*.

	<i>U. boeadii</i>	<i>U. emmae</i>
head body length	255	232
tail length	235	258
hindfoot (su) length	62.0	50.5
ear (notch) length	25.0	20.5
ear width	—	16.5
condylobasal length	61.3	53.0
bizygomatic breadth	32.2	28.0
incisive foramen length	7.8	5.7
interorbital breadth	10.9	9.2
upper molar row length	11.5	11.1
M <sup>1</sup> breadth	3.3	3.1
palate width (external) at M <sup>1</sup>	11.8	11.1
palate width (external at M <sup>3</sup> )	12.5	11.5
nasal length	25.1	19.3
nasal breadth (anterior)	7.9	6.1
nasal breadth (posterior)	4.0	3.5

Table 3. Derived characters used in cladistic analysis. Each character was binary coded only – 0 = absent, 1 = present.

1. Strong spine at back of palate	25. Coronoid process low, rounded
2. Incisive foramina slit-like	26. Dentary tubercle and ridge strongly developed
3. Zygomatic arches posteriorly flared	27. Ascending rami flare outward
4. Posterior walls of rostrum inflated, sloping-sided	28. Tail shorter than head + body
5. Lingual margins of molar alveoli thickened, ridge-like	29. Ear length greater than 40% of condylobasal length
6. Prominently swollen frontotemporal sutures	30. Hindfoot length usually less than 20% of head + body
7. Postorbital processes (behind frontotemporal sutures)	31. Feet light coloured (white or light brown)
8. Medial walls of orbitotemporal fossa sloping, not vertical	32. White on terminal part of tail
9. Anterior wall of orbit subvertical	33. Tail scales large, ridged, in rings
10. Posterior nasal ends tapered, narrow-arched	34. Tail scales broader than long
11. Posterior nasal ends extend behind anterior orbital margins	35. Underside with restriction of white zone
12. Lacrimal extends at least as far back as nasals	36. Incisive foramina long, greater than 20% of palate length
13. Coronal suture straight or only slightly bowed backward	37. Bullae inflated
14. Preorbital foramen not vertical	38. Feet narrow, their breadth less than 20% of their length
15. Lambdoid suture anteriorly angulated	39. Toothrow short, less than 20% of condylobasal length
16. Braincase rounded	40. M <sup>3</sup> reduced
17. Interorbital region inflated	41. Anterior lophid of mandibular M1 reduced
18. Zygomatic arches swing down towards molar alveoli	42. Molars simplified
19. Nasals protrude in front of snout	43. Pads of feet reduced in size
20. Nasal ends slightly upturned	44. Molars broadened
21. Incisors opisthodont (not orthodont)	45. Tail scales 9 or less per cm
22. Skull, especially rostrum, deepened	46. Palate greatly lengthened posteriorly
23. Long paroccipital processes	47. Interparietal bone elongated
24. Ascending ramus vertical, not backsloping	48. Anterolateral bullar spurs reduced
	49. Preorbital foramen hidden behind zygomatic plates

Table 4. Distribution of character states among species of *Uromys*. 0 = plesiomorphic, 1 = apomorphic. The columns are ordered sequentially as in Table 3.

<i>rex</i>	001001010111110000001111111000010000010000000000
<i>imperator</i>	1010010101001100000010100111000010000010001110000
<i>porculus</i>	0000010100001100000010100111000010000010000010000
<i>anak</i>	0101111010101000101101000000000011000001110001000
<i>neobritannicus</i>	0101101010101000001101000000000011000001110011000
<i>boeadii</i>	0101000000000000001001000000010000000001110001000
<i>emmae</i>	1111101011001001001100000000111100001001110001101
<i>caudimaculatus</i>	111110101100100111110000000011110001111110001100
<i>hadrourus</i>	1111100011001011011100000000111100111011110001110



## Some Larval Leptoceridae (Trichoptera) from South-eastern Australia

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**ABSTRACT.** Leptoceridae larvae belonging to 23 species in twelve genera are described, most for the first time. They are: *Triplexa villa* Mosely, *Condocerus paludosus* Neboiss, *Notoperata maculata* (Mosely), *N. sparsa* (Kimmins), *Symphitoneuria opposita* (Walker), *Lectrides varians* Mosely, *Triplectidina nigricornis* Mosely, *Triplectides similis* Mosely, *T. proximus* Neboiss, *T. elongatus* Banks, *T. varius* Kimmins, *T. truncatus* Neboiss, *T. altenogus* Morse & Neboiss, *T. australicus* Banks, *T. ciuskus* Mosely, *T. australis* Navás, *T. volda* Mosely, *T. magnus* (Walker), *Westriplectes pedderensis* Neboiss, *Leptorussa darlingtoni* (Banks), *Leptocerus sounta* Mosely, *Triaenodes volda* Mosely, and *Oecetis laustra* Mosely. Keys are provided for identification of larvae to generic level and for separation of two species of *Notoperata* and eleven species of *Triplectides*. On the basis of adult, larval and pupal characters, *Triplectides hamatus* Morse & Neboiss is here placed as a junior synonym of *T. truncatus*. Most of the species described here belong to the Triplectidinae which is confined to Australasia, southern Asia, and Central and South America. Comparisons are made with known larvae from these regions. Larval habitats are described.

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Despite the very widespread and common occurrence of leptocerids in Australia and the advanced state of taxonomic knowledge of the adults (Neboiss, 1983, 1986), very few larval descriptions are available. As a result, identification of larvae beyond family level is rarely possible. Overseas information is of limited value in identification of the larvae of Australian species as much of it refers only to one subfamily, the Leptocerinae. Indeed, available definitions of the family exclude larvae of many Australian species.

Larval descriptions from previous studies are available for only five species of Australian Leptoceridae:

*Lectrides varians* and *Leptorussa darlingtoni*, both described fully by Jackson (1985), *Notalina spira*, described as *Oecetis situlus* (Korboot, 1964a), *Triplectides volda* (Korboot, 1964b) and *Triaenodes bernaysae* (Korboot, 1964c). Korboot (1963) also provided notes on the larvae of *Triplectides volda*, *T. australis* and *Symphitoneuria exigua*.

Morse & Neboiss (1982) stated that the species identified by various authors as *Triplectides magnus* from Asia, New Zealand and other locations outside south-eastern Australia is probably some other species, possibly *T. australis*. This presumably applies also to the



incomplete larval descriptions of *T. magnus* by Tillyard (1925) and Ulmer (1906).

The phylogeny of the family Leptoceridae was first presented by Morse (1981), incorporating some studies by earlier workers, and has been refined since by Holzenthal (1986, 1988b) and Morse & Holzenthal (1987). These works place the genera into subfamilies and tribes but generally do not discuss the relationships within the tribes.

The Leptoceridae is divided into two subfamilies: Leptocerinae Leach and Triplectidinae Ulmer. The Triplectidinae is restricted to Australasia and the neotropics, but the Leptocerinae is cosmopolitan. Differences between larvae of the two subfamilies have been outlined by Ulmer (1955) and Cowley (1978), but fewer than ten species of Triplectidinae were included in these two studies.

There are six known Australian leptocerine genera (*Leptorussa*, *Russobex*, *Leptocerus*, *Triaenodes*, *Setodes* and *Oecetis*) and nine known Australian triplectidine genera (*Triplexa*, *Condocerus*, *Notalina*, *Notoperata*, *Lectrides*, *Symphitoneuria*, *Triplectidina*, *Triplectides* and *Westriplectes*).

The aim of this study is to describe larval Leptoceridae after association of reared larvae with adults. For practical reasons, collections were predominantly from Victoria although many of the species are not restricted to that state. The taxonomy of the family as detailed in Neboiss (1983) is followed and readers should consult this work for nomenclature and synonymy.

## Materials and Methods

Methods used for collecting, rearing and describing are as described in St Clair (1991). The only difference is due to loss of sclerites from pupal cases of some species described here. For such species, the contents of the rearing container were sorted under a stereo microscope to ensure as many sclerites as possible were retrieved. The Material examined section of each description lists reared males (ie, male adult or pupa, pupal skin larval sclerites and case), reared females and larvae, numbers without a symbol. Only specimens collected by people other than myself have the collectors' names listed. Specimens are lodged in the Museum of Victoria, numbers starting PT- are registration numbers. Terminology follows that of Wiggins (1977, 1984).

## Results

Twenty-three species are described here (and a further 8 in previous papers by St Clair, 1988, 1991) in the larval stage, most for the first time. Only one genus recorded from Australia was not found during this study. Larvae of this genus, *Setodes*, have been described from other countries (Wiggins, 1977; Wallace, 1981). Keys for identification of larvae to genera, and to species for

*Notoperata* and *Triplectides* are provided.

Although collections were mainly made in Victoria, published distribution records of adults (Neboiss, 1983) suggests the results have a wider applicability. Of the species considered, only four appear to be endemic to Victoria on available data; most species are found in other states and thus the keys provided are applicable to much of the south-eastern Australian region.

In Australia, Leptoceridae are common and widespread. The larvae of Leptoceridae can be found in a wide variety of aquatic habitats: streams (except for torrential stretches and sections lacking backwaters), swamps, lakes, temporary streams and ponds, saline lakes, saline creeks, estuaries and even the splash zone of waterfalls. Most larvae are associated with still or slow-flowing water, and are often in backwaters of an otherwise fast flowing stream. Few species occur in areas of high current speeds. The larvae are usually found on detritus, macrophytes or submerged riparian vegetation. In surveys of stream benthos, leptocerid numbers have frequently been underestimated owing to the tendency of the larvae of many species to be out of the main stream channel where sampling is usually conducted.

Larval Leptoceridae can be quite abundant; Metzeling *et al.* (1984) collected 2,334 *Notalina bifaria* larvae and 1,190 early instar *Notalina* larvae in ten 0.05 m<sup>2</sup> samples from one site on the La Trobe River, Victoria.

Several leptocerid species occur at a given site: seven species were collected from each of several sites during this study and 11 species have been recorded from a single site on the La Trobe River (Marchant *et al.*, 1984).

## Identification of Larvae

**Larval characteristics of Leptoceridae.** Most larval Leptoceridae described here are easily recognised by the presence of obvious long antennae on the anterior margin of the head capsule. In some species of *Oecetis* and all species of *Triplectides* the antennae are much shorter. Even in these two genera, the antennae are still considerably longer than those of most other families. The only exception is larvae of *Triplexa villa* (Fig. 2) which have tiny antennae situated nearly halfway between the eye and the anterior margin of the head capsule, comparable in position and length to those found in many other families.

Long hind legs are also characteristic of the family (Fig. 1). The trochanter is two-segmented with the second segment elongate (much longer than in most other families). The trochanter is longer on the posterior surface and apparently joins with the second segment of the femur. As the trochanter is fairly translucent, the first segment of the femur is usually visible through it. The femur is also divided into two segments. The first segment of the femur is very small and appears to be present only on the anterior surface of the leg (see Fig. 1). In *Lectrides*, *Symphitoneuria*, *Triplectides* and *Westriplectes* the tibia is divided into two segments, usually of about equal length. All species in this study

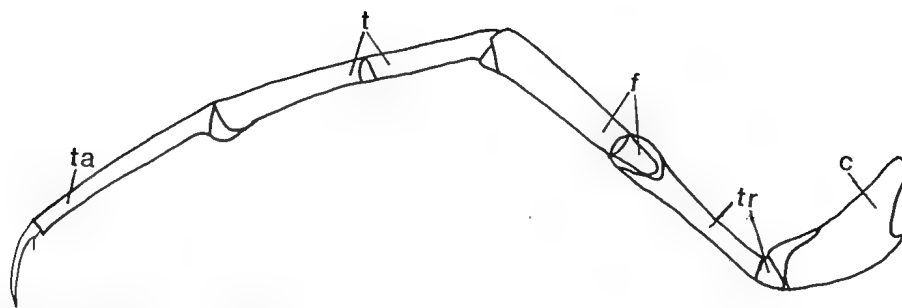


Fig. 1. Right hindleg of *Triplectides australis* larva, anterior view, c – coxa, tr – trochanter, f – femur, t – tibia, ta – tarsus.

displayed this basic leg configuration with only minor variability.

The following combination of characters define larval Leptoceridae; first abdominal segment with dorsal and lateral protuberances, anal claws with one or a few simple accessory hooks (not a comb-like structure), pronotum completely sclerotised, middle leg with tibia and tarsus not fused, without a median horn-shaped process on prosternum, metasternum with two, or (usually) more, setae on metasternum (J. Dean, personal communication).

Larvae of *Anisocentropus* (Calamoceratidae) are commonly confused with Leptoceridae. Larvae of *Anisocentropus* can be distinguished by the elongate forward directed processes on the pronotum (similar to that shown in fig.3.1 in Wiggins 1977) and the lack on setae on the metasternum.

All larvae examined in this study have a sclerite on the lateral humps of abdominal segment I and these sclerites are covered anteriorly with numerous very short pale setae. These setae are not shown in the figures.

**Subfamily characteristics.** Ulmer (1955) first compared larvae of the two subfamilies. However, his description of Triplectidinae was tentative as it was based on only two species. Cowley (1978) discussed the main characters distinguishing the two subfamilies in New Zealand, basing his findings on eight species. The following description of larvae for the two subfamilies is based on 26 Australian species of Triplectidinae and 15 Australian species of Leptocerinae. Information on non-Australian Leptocerinae is also used. The two subfamilies are found to be less distinct in the larvae than in the adults because the larval characters of two genera (*Leptorussa* and *Russobex*) are intermediate between those of the two subfamilies.

### Leptocerinae

There is no single diagnostic character for larvae of this subfamily. The most distinctive character is the presence of additional cephalic lines of weakness at which the primary sclerites usually subdivide at ecdysis (eg, Fig. 21A,E). These additional lines of weakness are considered characteristic of the entire family by Hickin (1967), Lepneva (1966), Wallace (1981) and Wiggins

(1977). In Australia, where larvae of both subfamilies are present, it is obvious that the lines of weakness are confined to the Leptocerinae. However, they are not present in all Leptocerinae, as they are absent in the two primitive genera *Leptorussa* and *Russobex*. These lines of weakness are present only in the fifth instar and may be difficult to see on pale specimens.

Generally the metanotum is not sclerotised, although North American species of *Mystacides* and *Nectopsyche* have small sclerites at setal area 3 (Wiggins, 1977). *Leptorussa* larvae have small medial metanotal sclerites, smaller but otherwise comparable with those of larval Triplectidinae.

The foretrochantin is short and obtuse (eg, Fig. 23J) in all Australian leptocerine larvae except *Leptorussa* and *Russobex*, in the latter two genera it is comparable with that of Triplectidinae larvae. Prosternal sclerites (as distinct from the narrow lateral sclerites at the posterior margin of the mesosternum) are absent. The lateral line is reduced and pale or absent. The head is often short ventrally but is long in some species. Often the ventral apotome does not completely divide the genae. The frontoclypeal apotome may have a constriction in a variable but species-specific position along its length.

Larvae swim by rapidly beating the hind legs back and forth. This has been observed in *Leptocerus*, *Triaenodes* and those species of *Oecetis* which characteristically make light cases consisting mainly of vegetable matter.

### Triplectidinae

There are no obvious diagnostic features of this subfamily. The following characters are useful in distinguishing triplectidine larvae, but are not characteristic because they are shared with one or both of the two primitive leptocerine genera. Additional cephalic lines of weakness are absent in all Triplectidinae, but also in the two most primitive leptocerine genera (*Leptorussa* and *Russobex*). The metanotum has at least two sclerites (sclerites only occur at setal area three when medial sclerites are present) in all species but also *Leptorussa*.

The foretrochantin is sinuous, long tapering (eg, Fig. 20B) in all Triplectidinae larvae but also in *Leptorussa* and *Russobex*.

One or two small sclerites are present centrally at the posterior margin of the prosternum although absent in *Notalina moselyi* Kimmins and *Triplexa villa* Mosely. The mesonotum has two sclerites near the midline at the posterior margin, more central than the sclerites of leptocerine larvae.

The lateral line is moderately long and thick (absent in *Triplexa* and short and fairly thin in *Notalina*), dark and distinct. Ventrally the head is moderately long, completely divided by the ventral apotome. The frontoclypeal apotome has a constriction at about half its length.

The larvae swim by rapidly flicking the head and thorax back and forth. Usually this is done with the larvae partly on their back. This has only been observed in larvae of *Notalina* and *Condocerus*.

### Difficulties with Subfamily Placement of Larvae compared with Adults

It is apparent from the above subfamily descriptions that four characters can be used to separate the two subfamilies: i) presence or absence of additional cephalic lines of weakness; ii) presence or absence of metanotal sclerites; iii) shape of foretrochantin; iv) presence or absence of prosternal sclerites. However, two genera (*Leptorussa* and *Russobex*) would be placed into the Triplectidinae using larval characters, while adult characters place them in Leptocerinae. This large difference between life history stages presumably arose from different rates of evolution in the larvae and adults, something that has been noted previously within the Trichoptera (Ross, 1967).

### Key to Genera for Mature Larvae of Australian Leptoceridae

1. Metanotum without sclerites (Leptocerinae except *Leptorussa*) ..... 2
- Metanotum with at least 2 sclerites (rarely very small or pale) (Triplectidinae and *Leptorussa*) ..... 5
2. Claw of midleg modified to form a hook; coronal suture indistinct; case made entirely or almost entirely of secretion, translucent (Figs 21, 24Q) ..... *Leptocerus*
- Claw of midleg simple; coronal suture distinct; case with plant or sand additions, opaque ..... 3
3. Hind tibia divided (rarely with the division faint); case of spirally arranged plant matter (Figs 22, 24R) ..... *Triaenodes*\*
- Hind tibia undivided; case other than of spirally arranged plant matter ..... 4
4. Ventral apotome short, indistinct, not completely dividing genae; mandibles greater than twice as long as wide, flat and with few teeth (Fig. 3C); labrum with numerous setae (Fig. 23) ..... *Oecetis*
- Ventral apotome moderately long and narrow, distinct, completely dividing genae; mandibles less than twice as long as wide, teeth arranged around a central narrow concavity; labrum with few setae ..... *Russobex*
5. Antennae (not including terminal hair-like segment) less than one-fifth the width of the anterior margin of frontoclypeal apotome (Figs 2, 9) ..... 6
- Antennae (not including terminal hair-like segment) longer than one-fifth the width of the anterior margin of the frontoclypeal apotome (Fig. 4) ..... 7

6. Antennae situated behind base of mandible on anterior margin of head capsule; half or less of the metanotum covered by sclerites (Fig. 9) ..... *Triplectides*
- Antennae nearly halfway between the anterior margin of the head capsule and the eye; much more than half of the metanotum covered by sclerites (Fig. 2) ..... *Triplexa*
7. Metanotum with 2 sclerites; some gills divided into at least 2 filaments ..... 8
- Metanotum with more than 2 sclerites; gills single filaments ..... 9
8. Metanotal sclerites very small but dark, rarely folded under front margin of segment; ventral apotome almost square ..... *Leptorussa*
- Metanotal sclerites larger but very pale; ventral apotome a narrow rectangle ..... an undescribed species of *Notalina* from North Queensland
9. Hind legs with tibia undivided (Fig. 4) ..... 10
- Hind legs with tibia divided (Fig. 1) ..... 12
10. Anterior margin of pronotum scalloped; corner of pronotum extended and/or cut away laterally (Fig. 5) ..... *Notoperata*
- Anterior margin of pronotum straight; corner smoothly rounded ..... 11
11. Metanotum with at least 6 sclerites; metasternum with about 8 setae, usually each with a small basal sclerite (Fig. 4) ..... *Condocerus*
- Metanotum with less than 6 sclerites; metasternum with numerous setae, none with a basal sclerite ..... *Notalina*
12. Anterolateral corner of pronotum brought to a slight point or smoothly rounded (Fig. 8) ..... *Triplectidina*
- Anterolateral corner of pronotum brought to an obvious elongate point (Fig. 7) ..... 13
13. Metanotum with 2 medial sclerites and either 2 distinct lateral sclerites on each side or these overlapped so appear as 1 long sclerite ..... *Lectrides*
- Metanotum with 2 short medial sclerites and 1 small lateral sclerite on each side (Fig. 7) ..... 13
14. Metanotum with a pair of long setae posterior to the medial sclerites; ventral apotome rectangular; tergite IX with 6 long and 4 short setae; metasternal setae each with a small basal sclerite (Fig. 7) ..... *Symphitoneuria*
- Metanotum without a pair of long setae posterior to the medial sclerites; ventral apotome tapering posteriorly; tergite IX with 4 long and 4 short setae; metasternal setae arising from 2 comparatively large sclerites (Fig. 20) ..... *Westriplectes*

\* The larvae of *Setodes* in Wiggins (1977) and Wallace (1981) would key out as *Trienodes* in this key, but without the characteristic case type. If the Australian species is similar to that figured by Wiggins and Wallace, it would differ from *Trienodes* in having a sand grain case and large sclerotised plates, spines or other armament on the end of the abdomen.

## Triplectidinae

### *Triplexa* Mosely

**Diagnosis.** The following characters define *Triplexa*: antennae very short and situated between the eye and the anterior margin of the head capsule; metanotal sa1 and sa2 sclerites separate but abutting; metapleural sclerites (but not mesopleural sclerites) unusually large.

**Remarks.** The larvae and pupae of *Triplexa* are very unusual with several character states that are quite atypical of the Leptoceridae. They are, however, very similar to the larvae and pupae of *Atanatolica* and, to a lesser extent, *Grumichella*, two Neotropical Triplectidine genera reviewed by Holzenthal (1988b). The unusual character states of *Triplexa* and *Atanatolica* are as follows (in brackets the usual state of the character): very short antennae (long antennae); coronal suture broad posteriorly (very narrow posteriorly); mandible without teeth (with teeth) and with one long setal brush in the central concavity of each mandible (Fig. 2,2A) (2 short setal brushes in the central concavity of the left mandible only); sclerotisation around the ventral apotome very light (sclerotisation normal); ventral apotome appearing not to reach the posterior margin of the head capsule and a ventral suture present (ventral suture absent); secondary setation on the head and pronotum (no secondary setation); metanotal sclerites fused or almost so and covering most of the segment (sclerites separate and covering less than half of the segment); metapleural sclerites unusually large; legs rounded in cross section (flattened); hind tibiae curved outwards (straight); long tapered sand case with a posterior silk section with a dorsal opening (straight and with a posterior opening, without a posterior silk section).

Some characters of interest were not mentioned by Holzenthal (1988b). The position of the antennae in *T. villa* and as shown for both *Atanatolica* and *Grumichella* is unique in the family. Larvae of *T. villa* are unique at least within the Australian Leptoceridae in having an accessory hook on the inner margin of the anal claw, although double accessory hooks are found on a neotropical species (probably *Atanatolica* sp.) figured by Botosaneanu (1974). *T. villa* larvae are also unusual in having stout dark peg-like setae on the anterior margin of the pronotum, however, similar setae are shown for the species regarded as *A. botosaneanui* by Holzenthal (1988b) (Botosaneanu & Flint, 1982: fig. 56). The metasternum of *T. villa* is unusual within the Australian Leptoceridae in having posterior sclerites and the gills are dorsoventrally flattened instead of rounded. However, no mention is made of either character in descriptions of *Atanatolica* larvae.

The larvae of *Triplexa* and *Atanatolica* are strikingly similar. From descriptions by Holzenthal (1988b), the only distinguishing features are: metanotal sa1 and sa2 sclerites completely fused in *Atanatolica*, separate but abutting in *Triplexa*; meso- and metapleural sclerites unusually large in *Atanatolica*, only metapleural sclerites

unusually large in *Triplexa*.

Holzenthal (1986) moved *Triplexa* from the tribe Hudsonemini to the tribe Grumichellini. He stated that "discovery of the immatures of *Triplexa* possibly will test this phylogenetic hypothesis since known Grumichellini immatures are highly derived with several striking homologous". Discovery of the immatures shows *Triplexa* to be very similar to *Atanatolica*, sharing all the striking homologies of that genus, fully supporting the inclusion of *Triplexa* in the Grumichellini.

Holzenthal (1986) also discusses the biogeography of Leptoceridae. He proposes a tropical component of the trans-Antarctic biota due to the presence of *Atanatolica* and *Grumichella* in Brazilian South America. The extreme similarity of larval *Triplexa* to *Atanatolica* and the tropical distribution of *Triplexa* is support for this argument. The larvae of *Triplexa psocoptera* from New Caledonia could provide further information for this proposal.

The distinctive features of larvae of this genus and of *Atanatolica* may be influenced by habitat. All Australian larval *Triplexa* were collected from the splash zone of waterfalls. A detailed description of a similar habitat was given for *A. dominicana* by Flint (1968), who noted that larvae were never submerged, and also for larvae of a species probably belonging to *Atanatolica* in Venezuela (Botosaneanu, 1974). Thus morphological modification may have arisen by adaptation to this almost terrestrial habitat.

Reduction of the lateral line and absence of prosternal sclerites, both characters otherwise only found in larval Leptocerinae and some *Notalina*, may also be influenced by the unusual larval habitat of *Triplexa*.

**Description.** Antennae short, much less than one-fifth width of frontoclypeal apotome on front margin; antennae situated nearly halfway between front margin of head capsule and eye, eye further from front of head capsule than in other Leptoceridae; without additional lines of weakness on head; ventral apotome very short, genae divided by ventral ecdysial line for most of their length, area around ecdysial line very pale and appears lightly sclerotised; labrum with very numerous secondary setae; mandibles short and wide, with ridge instead of teeth, both with several long setae in central concavity; pronotum with front margin straight, pronotum anterolateral corner rounded; foretrochantin sinuous, long tapering; metanotum extended posteriorly, mostly covered by 6 sclerites; metasternum with 5-14 setae without basal sclerites, but sclerites on segment medioposteriorly; hind tibia undivided; gills if present with several filaments, very flat; lateral line absent; tergite IX with 4 long and 6 short setae or with 8 long and 4 short setae; anal prolegs without secondary setation.

**Remarks.** There are only two species in this genus, *T. villa* from eastern Australia and *T. psocoptera* from New Caledonia.

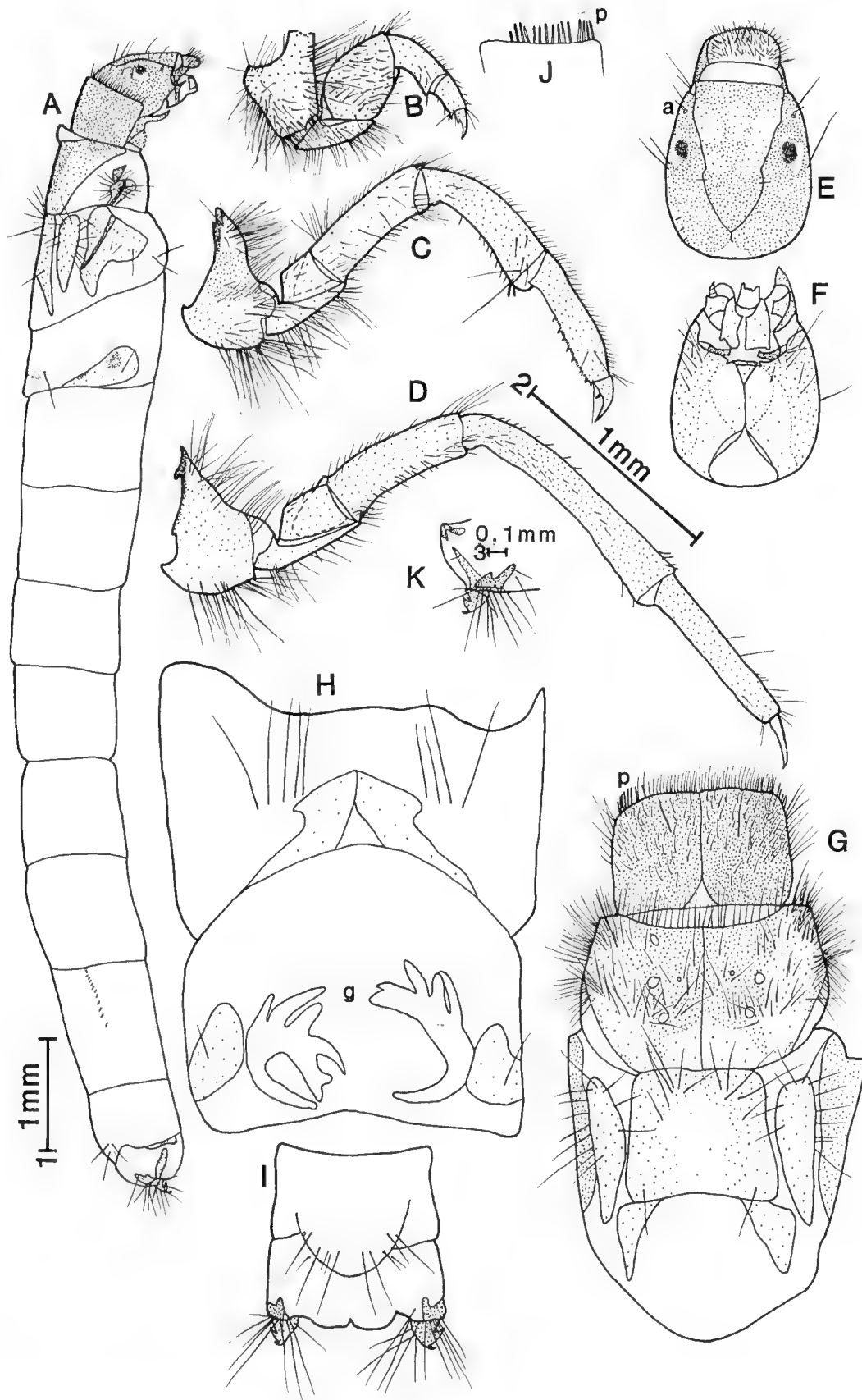


Fig. 2. *Triplexa villa* larva PT-957 (A-G, I-J) and PT-960 (H only). A – body lateral view, B – right foreleg, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – metasternum and segment 1 ventral view, I – segment IX dorsal view, J – right pronotal sclerite anterior margin, K – anal proleg. A – scale 1, B-J – scale 2. Secondary setation not shown on A or E. a – antenna, g – gills, p – peg-like setae.



*Triplexa villa* Mosely

Figs 2, 3A, 24A

**Material examined.** Three male and 3 female pupae, most with larval sclerites retained, and 85 larvae. NEW SOUTH WALES: Dorrigo National Park, Cedar Falls, 11 Dec. 1985, D. Bickel, 3 males pupae (incl. PT-958), 3 pupae (5 of the pupae retained the larval sclerites in the case), 3 (incl. PT-957); Dorrigo National Park at cascade in spray 16 Dec. 1984, A. Wells, 4. QUEENSLAND: Eungella National Park, tributary of Cattle Creek, M.J. Tyler, 26 Jan. 1984, 78 (incl. PT-960).

**Description.** *Head.* Width 0.42-0.63 mm. (n=31, 2 sites); oblong dorsally but wider posteriorly; brown with very pale area over region of coronal suture and pale brown patches on frontoclypeal apotome, ventrally very pale medially and brown laterally; frontoclypeal apotome long, very broad anteriorly, constriction slight; head covered with numerous setae in front two thirds (not figured); numerous setae on submental sclerites, palpifer and palps.

*Thorax.* Pronotum brown; anterior margin laterally with short black peg-like setae; prosternum without sclerites; foretrochantin very long and thin, upturned section at shallow angle to base; mesonotum extended laterally on front margin, mottled brown, paler laterally; metanotal sclerites arranged as in Figure 2, medial sclerites pale brown with pair of dark elongate spots anteriorly, some with very pale spots posteriorly, lateral sclerites pale brown, sometimes with pale spot each, medial posterior sclerites brown, sometimes curled so differing from Figure 2, metanotum often with small mesal sclerite on posterior margin; prosternum without sclerites; metasternal sclerites pale yellow; legs brown with paler areas on coxae, first segment of femur on mid- and hindleg black; leg segments rounded in cross-section; hind femora curved outwards; midleg with femur ventrally and whole of tibia and tarsus with a roughened appearance due to numerous, very short setae, hind leg similar on trochanter and femur ventrally and whole of tibia and tarsus.

*Abdomen.* Lateral hump sclerites very pale yellow with black patches, front half with numerous brown very

short projections instead of setae; gills present or absent, when present on segment 1 and possibly 2 and 3 dorsally, laterally and ventrally; gills strongly dorsoventrally flattened, divided into a variable number of filaments; tergite IX very pale, may be difficult to see, sometimes with pale brown spots; NSW specimens with either 8 long and 4 short setae or 4 long and 6 short setae; lateral sclerites and ventral sole plate dark brown; anal claw large with 1 comparatively large accessory hook on outer margin and 1 small accessory hook on inner margin of base of claw.

*Body length.* 6-10 mm.

*Case.* Tapering and curved tube made of small sand grains. Posteriorly with small tip made of secretion, curved upwards and with dorsal opening (Fig. 24A).

*Early instar larvae.* Larvae with head widths of 0.27-0.36 mm, n=6, were assumed to be in their fourth instar and those with head widths of 0.22 mm, n=2, were assumed to be in their third instar. These larvae were readily identified as most of the unusual characteristics of this species were present.

**Habitat and distribution.** All three collectors of larvae of this species noted on the label that the larvae were in the splash zone of a waterfall. These specimens were found further south and further north than the distribution of south-eastern Queensland given by Neboiss (1983).

*Condocerus* Neboiss

**Diagnosis.** The combination of 6 or 7 metanotal sclerites and hindleg with tibia undivided is sufficient to characterise this genus.

**Description.** Antennae (not including terminal hair-like segment) moderately long, close to one-quarter width of frontoclypeal apotome at front margin; labrum without secondary setae; mandibles short and wide, teeth grouped around central concavity, similar to Figure 3B but more slender; left mandible with 2 short setal brushes in central concavity; without secondary lines of weakness on head; ventral apotome long and tapering; pronotum front margin straight, pronotum anterolateral corner rounded; foretrochantin sinuous long tapering; metanotum with 6 or 7 sclerites; metasternum with 8-12 setae, usually each with small sclerite at base, roughly in transverse row; additional very short setae usually present, each with tiny basal sclerite; hind tibia undivided; gills single filaments; lateral line commences medially on segment III; tergite IX with 6 long and 4 short setae; anal prolegs with secondary setation.

**Remarks.** The two species in this genus are *C. paludosus*, described here, and *C. aptus*, which is confined to south-west Australia. Larvae from Western Australia, assumed to be those of *C. aptus*, agree with the generic description given here.

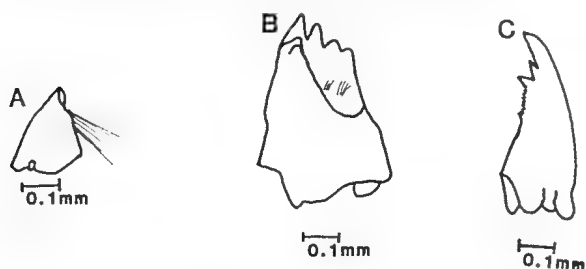


Fig. 3. Larval mandibles of A – *Triplexa villa* right mandible, B – *Triplectides ciuskus* left mandible, C – *Oecetis laustra* left mandible.



*Condocerus paludosus* Neboiss

Figs 4, 24B

**Material examined.** Eleven reared males, 4 reared females and 195 larvae. VICTORIA: Stony Creek at Turret Falls, 3 km south-west of Halls Gap, 4 Dec. 1983, 21; Dairy Creek, 6 km south of Halls Gap, 3 Nov. 1981, 1 male, 6; Mount Rosea Creek, 8 km west-south-west of Halls Gap, 2 Nov. 1981, 1; Wannon River, 25 km west-south-west of Halls Gap, 3 Nov. 1981, 1 male (PT-939); Ford River, 7 km south-east of Lavers Hill, 25 Oct. 1984, 4; Gellibrand River at Gellibrand, 25 Oct. 1984, 5; Coliban River at Trentham Falls, Trentham, 11 Nov. 1981, 1; Acheron River, 3.5 km east-south-east of Narbethong, 17 Nov. 1981, 26, 9 Feb. 1982, 1 male, 2 Dec. 1982, 2 males, 19 Jan. 1984, 1 female; tributary of the Howqua River, 18 km south-east of Merrijig, 31 Jan. 1982, 7; Acheron River at Taggerty, 19 Oct. 1984, 8; Big Pats Creek, 4 km east-south-east of Warburton, 6 Nov. 1983, 1; Toorong River at Falls, 6 km north-east of Noojee, 27 Nov. 1981, 11, 24 Jan. 1984, 1 male, 2 females; Mount Bogong, tributary of Middle Creek, 3 km east-south-east of Cope Hut, 1 Oct. 1982, 1 male, 4; Little Snowy Creek at Eskdale, 30 Nov. 1982, 6; Barkly River, 9 km north-west of Licola, 7 Nov. 1984, 2; Dinner Creek, 15 km north-north-east of Licola, 7 Nov. 1984, 2 males, 1 female, 8; Wellington River, 11 km north of Licola, 6 Nov. 1984, 7; Moroka River, 10 km east of Mount Wellington, 7 Nov. 1984, 23; Wonnangatta River at Waterford, 8 Nov. 1984, 1 male (incl. PT-987); Dargo River, 6 km north of Dargo, 8 Nov. 1984, 1 male, 38 (incl. PT-910); Murray River at Tom Groggin, 19 Nov. 1982, 2; Rodger River, 23 km south-west of Bonang, 1 Nov. 1983, 6; Bonang River on Bendoc-Orbost Road, 29 Jan. 1983, 3; West Errinundra River, 5 km north of Errinundra, 31 Dec. 1982, 44; east branch of the East Errinundra River, approximately 23 km south-east of Bonang, 24 Jan. 1983, 5.

**Description.** *Head.* Width 0.55-0.63 mm (n=36, 4 sites); oblong dorsally, slightly narrower anteriorly, brown with scarcely contrasting pale spots and few contrasting darker spots, some specimens with pale stripe on each side of frontoclypeal apotome in front of constriction, much paler laterally and ventrally with contrasting dark spots, some specimens with dark patch on posterior margin ventrally; frontoclypeal apotome widest on its anterior margin, rounded and tapering behind constriction; ventral apotome strongly tapering, narrow in distal half (some specimens more so than others); left mandible with 6 teeth; right mandible with 5 teeth.

*Thorax.* Pronotum pale brown, paler at front and sides; mesonotum pale brown with darker spots; metanotal sclerites brown, arranged as in Figure 4; foretrochantin short, with long upturned section; prosternal sclerites brown, with or without pale forward extension at medial edge; mesosternal sclerites comparatively small, pale brown with darker anterior margin; metasternum with 4-18 additional short setae, usually in clump at each side of segment anterior to main row of setae; legs pale yellow to pale brown, unbanded; hind legs with several long spines ventrally; thorax often with scattered short setae usually with tiny sclerite at base.

*Abdomen.* Lateral hump sclerites pale, often additional short setae scattered on segment I each with tiny sclerite at base; most specimens with 3 pairs of very short gills,

all dorsal, on segments 3-5 inclusive; tergite IX pale brown in some specimens to pale yellow with pale brown spots or patches in others; lateral sclerites very pale yellow anteriorly to pale brown posteriorly, darker in some specimens, some with pale brown spots anteriorly; ventral sole plates pale yellow, darker on some; anal claws comparatively small, with 2 nearly parallel accessory hooks on outer margin; many specimens with 6 anal gills extruded.

*Body length.* 6-12 mm.

*Case.* Made of small pieces of plant matter, often green, arranged to form tapering tube. Usually with additional long sections of detritus on sides and back looking as though they act like stabilisers. Tube usually about one and a half times larval length but case often longer due to long 'stabilisers' (Fig. 24B).

*Early instar larvae.* Larvae of *C. paludosus* can be identified also in fourth and third instar by row of 8 setae on metasternum, metanotal sclerites (although these may be pale) and presence of long spines on legs. Head widths of fourth instar larvae: 0.33-0.39 mm (n=7), third instar: 0.22-0.23 mm (n=2).

**Habitat and distribution.** Larvae were collected in streams ranging from alpine creeks to warm lowland rivers, and all with permanent flow. They were virtually always found on the water's surface with the case attached by silk to detritus in midstream or riparian vegetation. Larvae lie facing upstream with legs held out wide.

Collection of specimens from the Murray River and far East Gippsland suggest this species occurs in New South Wales, as well as Tasmania and Victoria, as recorded in Neboiss (1983).

*Notalina* Mosely

Larvae of seven species in this genus have been described (St Clair, 1991). The mandibles of these species are similar to that of Figure 3B, but more slender.

*Notoperata* Neboiss

**Diagnosis.** This genus can readily be identified with the following combination of characters; anal proleg without secondary setae, hind tibia undivided, and pronotum anterior margin with projections and an extension on the pronotum anterolateral corner.

**Description.** Antennae long, about one-third the width of frontoclypeal apotome at anterior margin; labrum without secondary setae or with transverse row of several setae anteriorly; mandibles short and wide, teeth grouped around central concavity, similar to Figure 3B; left mandible with 2 short setal brushes in central concavity; ventral apotome long and narrow; without secondary lines of weakness on head; pronotum anterior

margin scalloped, anterolateral corner extended; foretrochantin sinuous, long tapering; metanotum with 4 sclerites; metasternum with 9-31 setae, these without obvious basal sclerites or with very small, very pale sclerites; hind tibia undivided; gills single filaments; lateral line starts anteriorly on segment III; tergite IX with 6 long and 4 short setae; anal prolegs without secondary setation.

**Remarks.** This description applies to *N. maculata* and *N. sparsa* from south-eastern Australia and *N. tenax* from Western Australia, although comparatively few specimens of each were examined.

Larvae of the other two species in this genus (*N. diversa* and *N. syncope*), both from Western Australia, are unknown. The following key separates the two species from south-eastern Australia:

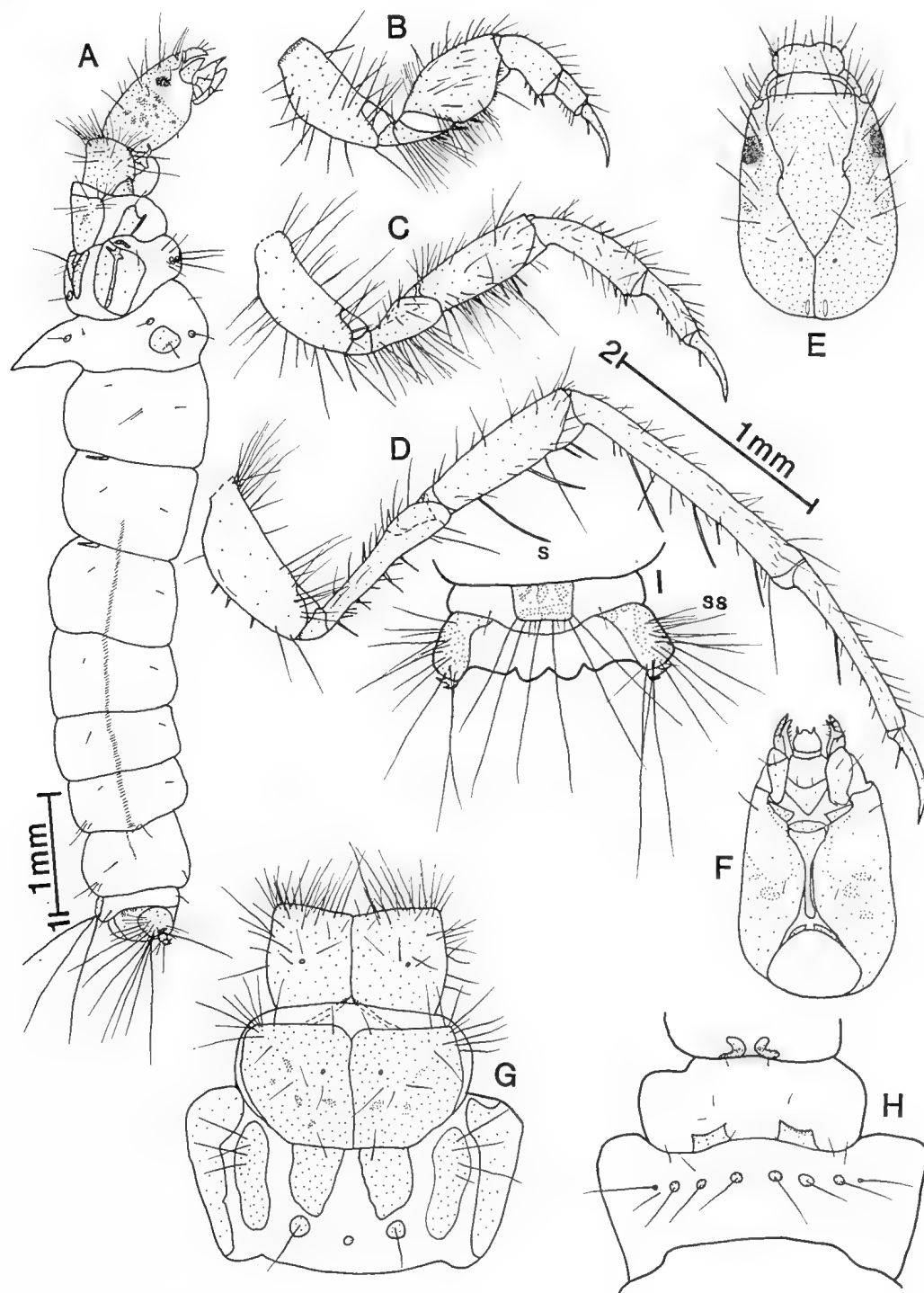


Fig. 4. *Condocerus paludosus* Neboiss larva (PT-910). A - body lateral view, B - right foreleg, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - thorax ventral view, I - segment IX dorsal view. A - scale 1, B-I - scale 2. s - long spines, ss - secondary setae on anal proleg.

1. Metanotal medial sclerites longer than wide; pronotum anterolateral corner scooped out laterally ..... *N. sparsa*
- Metanotal medial sclerites about as long as wide; pronotum anterolateral corner elongate ..... *N. maculata*

*Notoperata maculata* (Mosely)

Figs 5, 24C

**Material examined.** Ten reared males, 10 reared females and 11 larvae. VICTORIA: Mount Buffalo, sphagnum bog 300 m south-east of Tatra Inn, 5 Dec. 1982 and 27 Nov. 1982, 7 males, 8 females, 7 (incl. PT-954); 4 km north of Mount Wellington, small creek in snowgrass plain, 6 Nov. 1984, 3 males (incl. PT-955), 2 females, 4.

**Diagnosis.** The following combination of character states, in addition to those used in the key, distinguishes this species from the only other known species in this genus, *N. sparsa* (for which character states are shown in brackets): frontoclypeal apotome with only a slight constriction, almost triangular behind the constriction (rounded and tapering); metanotal medial sclerites shorter than lateral (as long or longer); metasternum with more than 20 setae (less than 20 roughly in 2 clumps, most setae with very small, very pale sclerite at base). The case is also distinctive, longer and with the detritus somewhat spirally arranged in *N. sparsa*. Habitat may also provide useful information for separation as *N. maculata* is only known from alpine sphagnum bogs and creeks and *N. sparsa* is only known from swampland in low areas of Wilson's Promontory.

**Description.** *Head.* Width 0.75-0.88 mm (n=11, 2 sites); oblong dorsally, slightly wider posteriorly; brown with few often poorly contrasting spots, long pale patch on both sides of frontoclypeal apotome posteriorly; frontoclypeal apotome, widest on anterior margin, with only slight constriction, almost triangular behind constriction; ventral apotome tapering to be narrow and rounded posteriorly and about one-third the anterior width; left mandible with 6 teeth; right mandible with 5 teeth.

*Thorax.* Pronotum brown, paler anteriorly, with poorly contrasting light brown spots, anterolateral corner elongate; mesonotum light brown with pale yellow spots, some spots with brown margin; metanotal sclerites arranged as in Figure 5, pale yellow, medial sclerites shorter than lateral sclerites, pair of short and long setae posterior to medial sclerites; foretrochantin with moderately long upturned tip; prosternal sclerites pale brown; mesosternal sclerites pale yellow; metanotal medial sclerites shorter than lateral sclerites; metasternum with 22-31 setae; legs mottled brown.

*Abdomen.* Lateral hump sclerites pale yellow; gills as in diagram in table 1, even on specimen reared for 8 months; tergite IX very pale yellow, difficult to see; lateral sclerite pale brown; ventral sole plate very pale

yellow; anal claw with 2 accessory hooks on outer margin.

*Body length.* 10-11 mm.

*Case.* Tubular, slightly wider anteriorly and often slightly longer dorsally so that small hood is formed. Made of detritus; medium sized rectangular pieces, small thin strips and small round pieces put together with no apparent pattern. Case about one and a half times the length of larva (Fig. 24C).

**Remarks.** Larvae of the two species from south-eastern Australia are similar, but the adults are strikingly so.

**Habitat and distribution.** Larvae of this species have only been collected from alpine areas, usually in sphagnum bogs, rarely in creeks. However, adults have been collected from much lower altitudes but searches for larvae at these sites were unsuccessful. This species has been recorded from North Queensland (Benson & Pearson, 1988), greatly extending the range of south-east Queensland, New South Wales, Victoria and Tasmania (Neboiss, 1983) and unlikely to be near sphagnum bogs.

*Notoperata sparsa* (Kimmins)

Figs 6, 24D

**Material examined.** VICTORIA: Wilson's Promontory, swamp on Five Mile Track 1 km east of Tidal River Road, 6 Nov. 1986, 3 males (PT-972), 5 females, 22 (incl. PT-962).

**Diagnosis.** See diagnosis section for *N. maculata*.

**Description.** *Head.* Head width 0.75-0.81 mm, n=8; oblong dorsally; very dark brown to almost black with strongly contrasting orange spots, lateral band of spots, ventrally with few spots posteriorly, antennae brown; frontoclypeal apotome widest on anterior margin, rounded and tapering behind constriction; ventral apotome tapering but still comparatively broad posteriorly, rarely narrow posteriorly; labrum with few setae; left mandible with 5 teeth; right mandible with 5 or 6 teeth.

*Thorax.* Pronotum anterior margin concave anteriorly, anterolateral corner scooped out laterally; dark brown with strongly contrasting orange spots posteriorly; mesonotum brown, yellow-brown posteriorly with contrasting yellow spots; metanotum with sclerites anteriorly as shown in Figure 6, medial sclerites as long or longer than lateral sclerites, medial pair pale brown with diffuse yellow spots, lateral pair pale yellow,

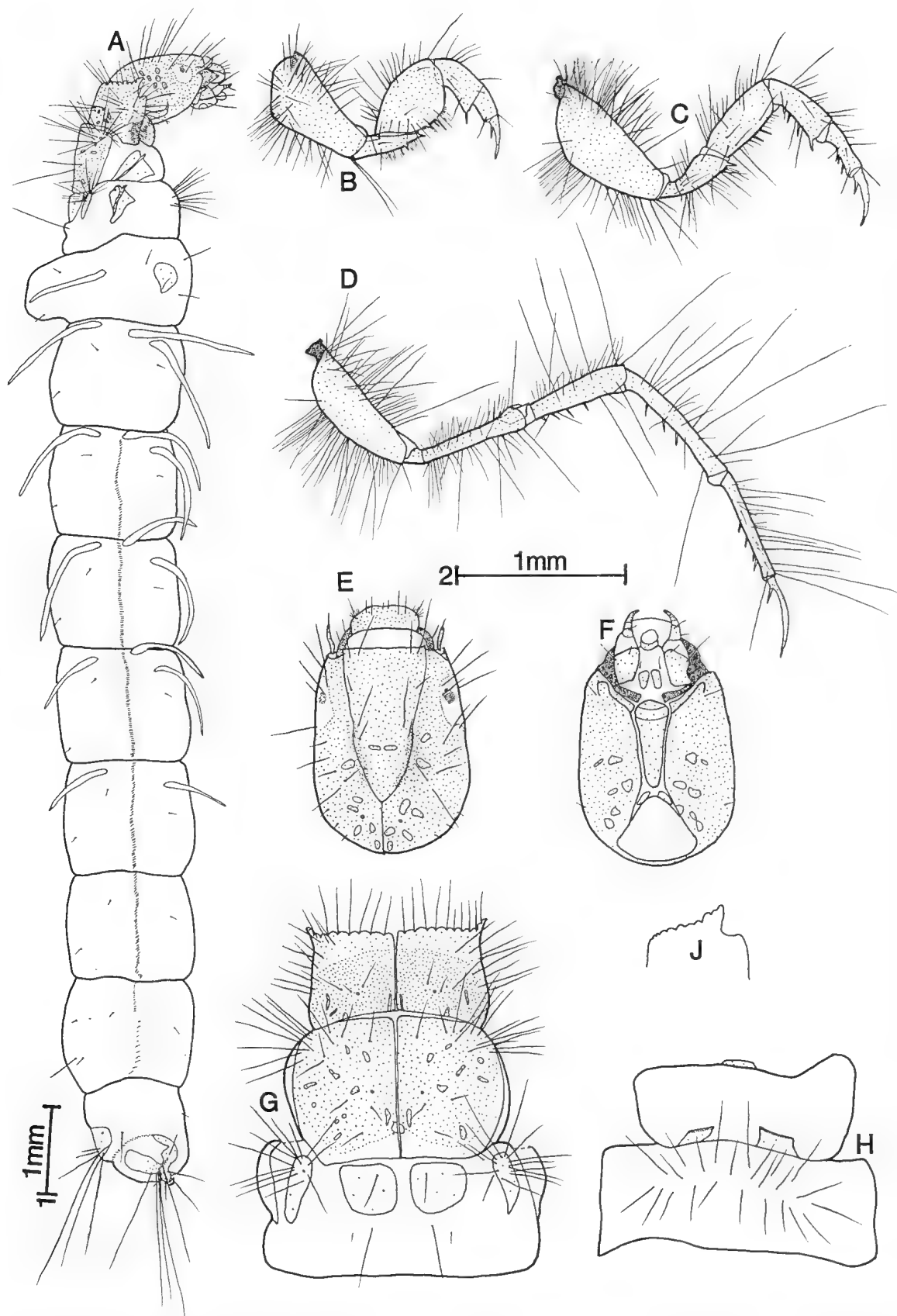


Fig. 5. *Notoperata maculata* larva (PT-954). A – body lateral view, B – right foreleg, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner. A – scale 1, B-J – scale 2.

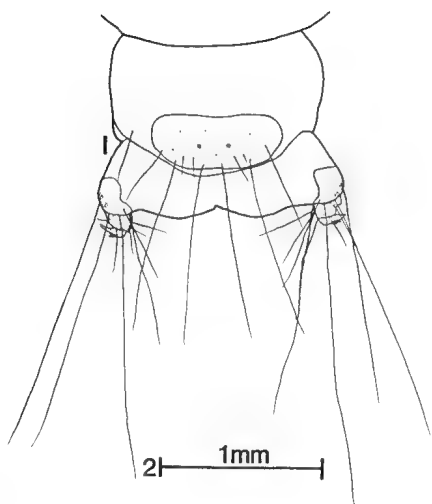


Fig. 5 cont'd.

posteriorly on segment 1 pair of short setae and 1 pair of long setae; foretrochantin with upturned section short and thin; prosternal sclerite pale brown; mesosternal sclerite pale brown, rarely with pale yellow spots, metasternum with 10-13 setae roughly in 2 clumps, most setae with a very small, very pale sclerite at base; foreleg and midleg with brown coxae, rest of leg light brown and orange; hindleg yellow with brown bands.

**Abdomen.** Lateral hump sclerites very pale and difficult to see; gills single filaments, arranged as in diagram in table 1, most with fewer than maximum number shown; lateral line moderately short and moderately dark; tergite IX very pale yellow anteriorly, orange posteriorly; ventral sole plate orange; anal claw moderately long with 2 nearly parallel accessory hooks on outer margin.

**Body length.** 12-13 mm.

**Case.** Made of spirally arranged rectangular and irregular pieces of brown detritus. Very long and thin, commonly about 5 times length of larva but only 2-3 mm diameter. Larvae do not swim with their case.

**Early-instar larvae.** One fourth instar larva, head width 0.5 mm, fits above description apart from being paler and less sclerotised and ventral apotome narrower posteriorly.

**Habitat and distribution.** Larvae of this species are only known from one locality, a swamp on Wilson's Promontory, with humic water and extensive submerged and emergent macrophyte growth. This is the first record of this species outside Tasmania.

### *Lectrides* Mosely

**Diagnosis.** The diagnostic characters are: antennae longer than half the width of the frontoclypeal apotome on anterior margin; hind tibiae divided; pronotum anterolateral corner extended and anterior margin

scalloped; metanotum with 6 sclerites, occasionally the 2 pairs of lateral sclerites fuse to form 1 long pair.

**Remarks.** The species of this genus known in the larval stage are very similar to those of *Symphitoneuria*, *Triplectidina* and *Westriplectes*. Larval *Lectrides* differ from larvae of the other three genera predominantly in possession of two pairs (or 1 long pair) of lateral metanotal sclerites and a pair of setae on the metanotum posterior to the medial sclerites.

**Description.** Antennae long, about half width of frontoclypeal apotome at anterior margin; labrum without secondary setae; mandibles short and wide, teeth grouped around central concavity, similar to Figure 3B but little more slender; left mandible with 2 short setal brushes in central concavity; ventral apotome moderately long, moderately broad anteriorly; without secondary lines of weakness on head; pronotum anterolateral corners with long projection, anterior margin scalloped; foretrochantin sinuous, long tapering; metanotum with 6 sclerites, a pair of setae present at setal area 3; metasternum with 8-14 setae, most or all with small sclerite at base; hind tibia divided; gills single filaments; lateral line starts anteriorly on segment III; ninth tergite with 6 long and 4 short setae; anal proleg without secondary setae; abdomen dorsoventrally flattened.

**Remarks.** There are two species in this genus: *L. varians*, described here, and *L. parilis* from Western Australia. Larvae from Western Australia, presumed to be those of *L. parilis*, were examined and included in the generic description.

### *Lectrides varians* Mosely

**Material examined.** Twenty-four reared males, 29 reared females and 110 larvae. VICTORIA: Stony Creek at Turret Falls, 3 km south-west of Halls Gap, 4 Dec. 1983, 3 females, 3; Lerderderg River, 4.8 km west-north-west of Blackwood, 27 June 1982, 2 males, 1 female, 29 July 1982, 1 male, 26 Feb. 1984, 4 males, 6 females, 15 Oct. 1985, 16; Shaws Lake, Blackwood, 15 Nov. 1985, 1 male, 1 female, 19; Jock Marshall Reserve, Monash University, Clayton, Melbourne, 14 Mar. 1985, 5; Acheron River at Taggerty, 30 Jan. 1982, 4 males; Acheron River at Acheron, 30 Jan. 1982, 1 female; Sheepwash Lagoon approximately 10 km north-east of Yea, 2 Oct. 1982, 1 female; Seven Creeks, 1 km south-east of Strathbogie, 1 Feb. 1982, 2 males; Big River, 10 km south-west of Jamieson, 30 Jan. 1982, 1 female; King River at Cheshunt, 2 Oct. 1982, 1 male; Ovens River at Porepunkah, 2 Oct. 1982, 1 female; Billabong approximately 3 km north of Eskdale, 30 Sept. 1982, 1 female; Mount Buffalo, Lake Catani, 5 Dec. 1982, 1 female, 4; Cobannah Creek, 4 km east-south-east of Cobannah, 15 Nov. 1983, 2; Pond beside Moroka River, 10 km east of Mount Wellington, 7 Nov. 1984, 1; Merrijig Creek, 7 km north-north-west of Bullumwaal, 16 Nov. 1983, 2 males; Prospect Creek, 5 km north-west of Mount Taylor, 15 Nov. 1983, 1 female; Rich River, 26 km north-north-east of Orbost, 14 Oct. 1982, 5 males, 5 females; Brodribb River, 24 km north-north-east of Orbost, 14 Oct. 1982, 1 female; Back Creek, 1 km north-

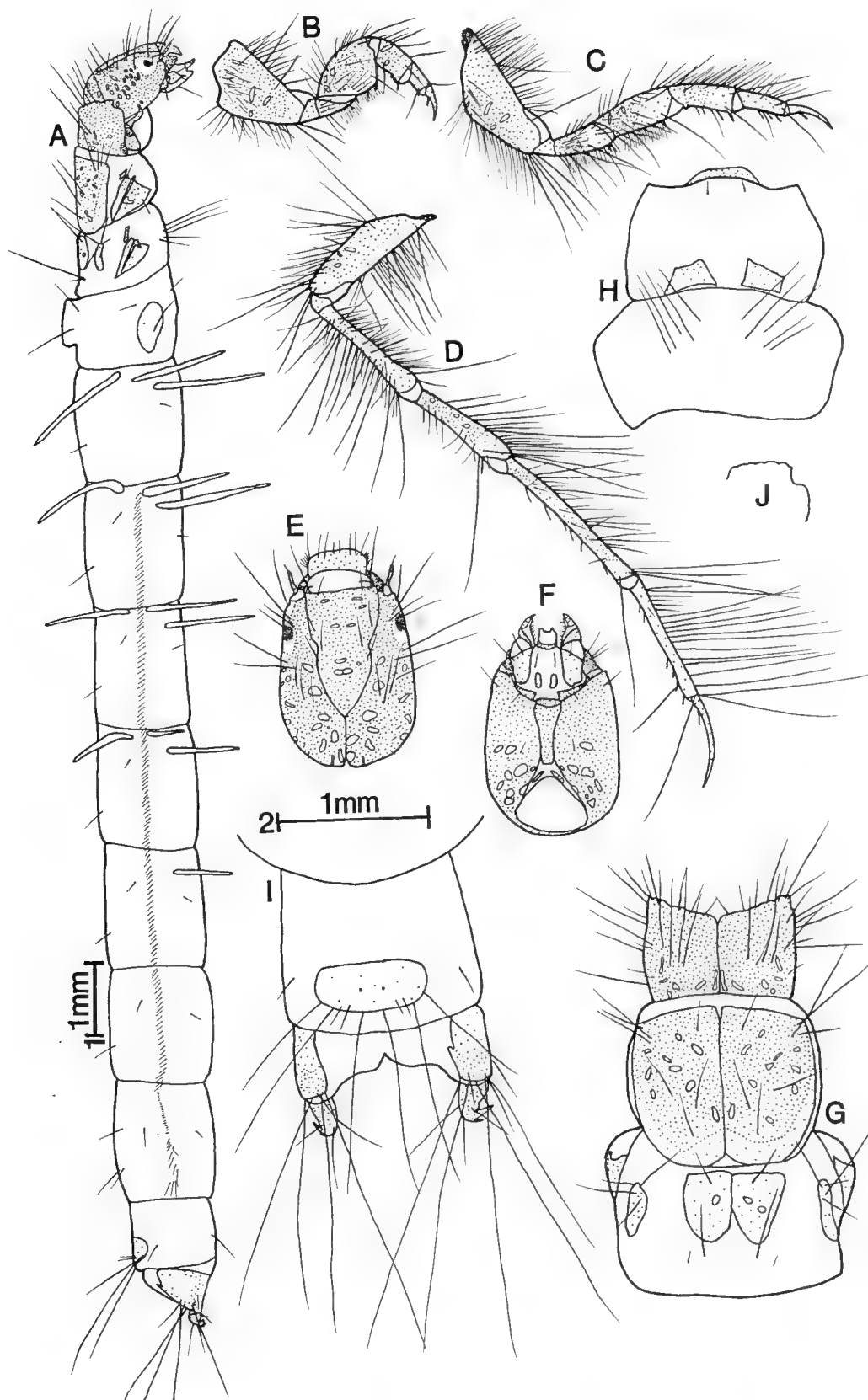


Fig. 6. *Notoperata sparsa* larva (PT-962). A - body lateral view, B - right foreleg, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - thorax ventral view, I - segment IX dorsal view, J - right anterolateral pronotum corner. A - scale 1, B-J - scale 2.



east of Noorinbee North, 13 Oct. 1982, 1 female; Rodger River, 23 km south-west of Bonang, 2 Nov. 1983, 1 male, 3 females, 11; Wigan River on Princes Highway, East Gippsland, 3 Jan. 1982, 2 males, 2 females, 11; east branch of East Errinundra River, approximately 23 km south-east of Bonang, 24 Jan. 1983, 7; Betka River, 6 km west-south-west of Mallacoota, 5 July 1983, 6.

**Comments.** The larva of this species was described and figured from South Australia by Jackson (1985). The following description includes only additional notes to her description and indicates the range of variation in Victorian specimens.

**Description.** *Head.* Width 0.61-0.81 mm (n=48, 6 sites); orange or golden brown or brown, with yellow spots, some specimens with pale area at back of head on each side dorsally; frontoclypeal apotome only slightly wider to much wider behind constriction than on anterior margin, usually irregular suture line behind constriction, rarely straight; left mandible with 5 or 6 teeth.

*Thorax.* Spots on pronotum with distinct or indistinct margins; metanotal lateral sclerites sometimes overlap giving appearance of 1 long sclerite on each side; metasternum with 6-10 setae, most commonly 8, each with small sclerite at base, rarely 2 sclerites join so that 2 setae arise from 1 sclerite.

*Abdomen.* Gills as in diagram in table 1; larvae from creeks with low water temperatures usually have close to number of gills shown and these are comparatively short; larvae from lakes or streams with warmer water temperatures have close to maximum number of gills shown and these are comparatively long; spicules large and obvious; anal claws with 2 accessory hooks on outer margin, 1 parallel to claw and 1 large one at an angle to it but their bases adjacent.

*Case.* Usually about one and one-half to 2 times body length.

*Early instar larvae.* The case is a very useful aid in identification of even tiny larvae, although it may be similar to case of early instar *Westriplectes* which is unknown for early instar larvae. Towns (1983) notes that *L. varians* hatchlings make distinctive case. Fourth instar larvae (head width 0.42-0.48 mm, n=12) are recognisable from above description. Third instar larvae (head width 0.31 mm n=1) have metanotal lateral sclerites very pale, frontoclypeal apotome straight behind constriction and pronotum anterolateral corner rounded but with deep indentation on lateral margin.

**Remarks.** Some very pale specimens with metasternal sclerites, metanotal sclerites (particularly lateral sclerites) and ninth tergite difficult to see, legs slightly banded or without pigment bands.

The cases of the two species in this genus are very similar but some larvae of *L. parilis*? have cases made of only two leaf pieces as is typical of *Anisocentropus* (Calamoceratidae). A photograph of the larva of *L. varians* was provided by Towns (1983).

**Habitat and distribution.** This species occurs in the widest variety of habitats of any species in this study.

It is found closely associated with detritus in backwaters of streams from cool foothills streams to warm lowland streams and including temporary streams. It also occurs in lakes from alpine areas to lowland. As the species is recorded as widely distributed from south-east Queensland, Victoria and Tasmania (Neboiss, 1983), its absence from New South Wales is probably an artefact of collection.

### *Symphitoneuria* Ulmer

**Diagnosis.** The diagnosis is as for *Lectrides* with the exception of possessing a total of 4 metanotal sclerites with the lateral pair short. See remarks section for *Lectrides*.

**Description.** Antennae long, nearly half as long as anterior margin of frontoclypeal apotome; labrum without secondary setae; mandibles short and wide, teeth grouped around central concavity; left mandible with 2 short setal brushes in central concavity, similar to Figure 3B; ventral apotome moderately long and moderately broad; without secondary lines of weakness on head; pronotum anterolateral corner extended, scooped out laterally, anterior margin scalloped; foretrochantin sinuous, long tapering; metanotum with 4 small sclerites, lateral sclerites particularly small; metasternum with 18-50 setae, most with very small pale sclerite at base; hind tibia divided; gills single filaments (apart from figured specimen); lateral line starts anteriorly on segment III; tergite IX with 6 long and 4 short setae; anal prolegs without secondary setae.

**Remarks.** This description is based on only one of the five species in the genus. Larvae of the other two Australian species (*S. exigua* [McLachlan] and *S. wheeleri* Banks) and the two New Caledonian species are unknown.

### *Symphitoneuria opposita* (Walker)

Figs 7, 24E-G

**Material examined.** Ten reared males, 18 reared females and 27 larvae. VICTORIA: Gnarkeet Creek, 10 km north-east of Lismore, 23 Oct. 1984, 3 females, 2; Balcombe Creek, near Balcombe Army Camp, Nepean Highway, Mornington, 14 Oct. 1984, 2 (incl. PT-949), 23 Dec. 1984, 2 males, 1 female; Balcombe Creek on Bungower Road, Mornington, 11 Jan. 1982, 2 females, 1; Yallock Creek, 2 km south-south-east of Koo-wee-rup 1980, 3 females; Wilsons Promontory, swamp on Five Mile Track 1 km east of Tidal River, Road. 6 Nov. 1986, 1; Ewings Morass, 11 km south-east of Nowa Nowa, 15 Oct. 1982, 1 male (incl. PT-912), 1; Ewings Morass, 15 km south-east of Nowa Nowa, 15 Oct. 1982, 6 males, 5 females, 14; Simpsons Creek, 11 km south-west of Orbost, 14 Oct. 1982, 2 males, 4 females, 6. SOUTH AUSTRALIA: Eight Mile Creek at mouth, 8 km east of Port MacDonnell, 21 May 1984, 1 male, 1.



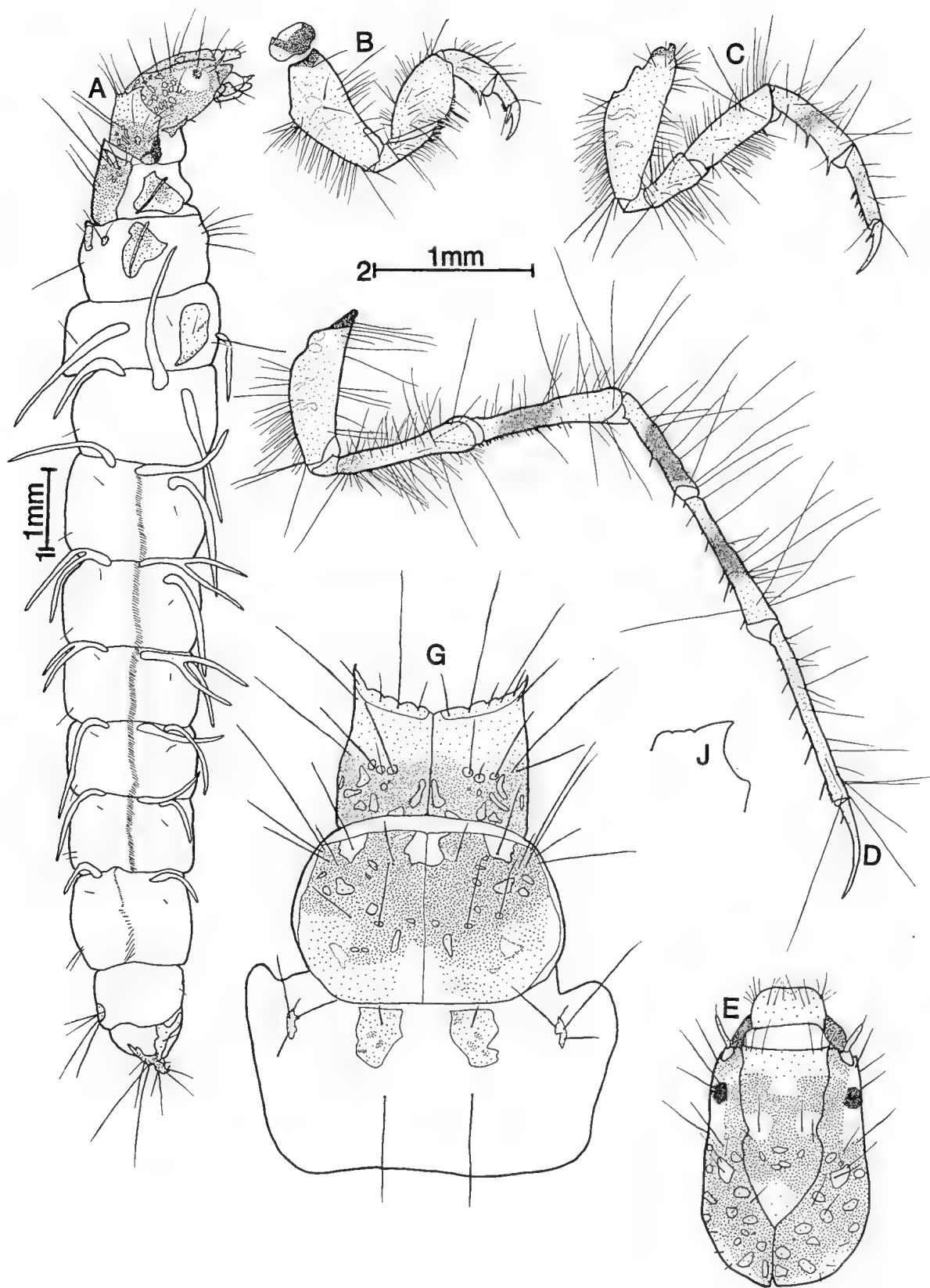


Fig. 7. *Symphitoneuria opposita* larva (PT-949). A – body lateral view, B – right foreleg, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner. A – scale 1, B–J – scale 2.

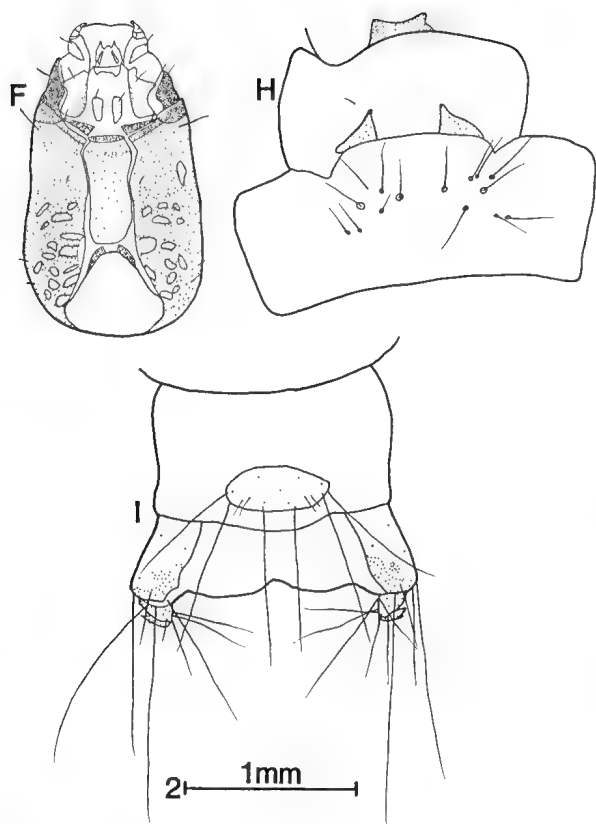


Fig. 7 cont'd.

**Description.** *Head.* Width 0.72-0.81 mm (n=22, 4 sites); oblong dorsally; brown or black with lightly or strongly contrasting yellow patches and spots, always 4 yellow areas on frontoclypeal apotome: 1 in posterior tip, 1 on each side at constriction and 1 on anterior margin medially; pale area at back of head may extend forward on each side dorsally or ventrally; paler ventrally, ventral apotome paler still; frontoclypeal apotome widest on anterior margin, sides usually straight behind constriction then tapering, but variable; ventral apotome scarcely tapering posteriorly; left mandible with 6 teeth; right mandible with 5 teeth.

*Thorax.* Pronotum dark brown or black, anterior third yellow or orange and strongly contrasting with rest of segment, some specimens with 2 pale patches anteriorly in midline corresponding with those on mesonotum; small spots yellow; mesonotum usually dark brown, paler posteriorly, spots yellow, usually strongly contrasting; metanotal sclerites arranged as in Figure 7, medial sclerites grey to brown with darker spots and sometimes with dark borders, rarely all very pale and difficult to see; foretrochantin long with thin sharply upturned point; prosternal sclerite brown; mesosternal sclerites pale brown, may join in middle; legs usually pale brown with pale yellow spots, some with brown bands on midlegs and hindlegs.

*Abdomen.* Lateral hump sclerites yellow with brown stem; gills as in diagram in table 1, only figured specimen had divided filaments; tergite IX very pale, often difficult to see; lateral sclerites and ventral sole plates pale yellow with pale brown or brown sides; anal

claw moderately small, with one, rarely 2, accessory hooks on outer margin.

*Body length.* 6-12 mm.

*Case.* Larvae of this species were found in several case types during this study but most may have been modified in the laboratory. The main types are: i) long thin pieces of twigs, bark and leaves in loose spiral arrangement, and in ti-tree (*Leptospermum*) swamps small ti-tree leaves are used extensively (Fig. 24G); ii) numerous small to very small sand grains with some grains protruding to give roughened surface, usually there is detritus section as well (Fig. 24E), sand and snail shells are also used in predominantly detritus cases; and iii) fewer larger pieces of detritus resulting in an untidy broad, less tubular case (Fig. 24F) similar but less regular than that of *Triplectidina nigricornis* or, when flattened, a less extreme form of the *Lectrides varians* case (Jackson, 1985). All three case types are long and tubular, and wider when detritus is used. Most have the dorsal surface longer than the ventral so that small hood is formed. The case is usually twice as long as larva, or longer.

**Remarks.** A brief description of the larva of *S. exigua* was given by Korboot (1963), but insufficient detail was given to enable species identification or comparison with the generic description given above.

**Habitat and distribution.** This species is usually found in small, sluggish, often turbid lowland streams and swamps. It is often associated with ti-tree swamps or ti-tree lined creeks. A few specimens were found in Gnarkeet Creek, Victoria, a slightly saline creek. The collection of specimens in South Australia near the Victorian border provides a small range extension outside that published of Victoria and Tasmania (Neboiss, 1983).

### *Triplectidina* Mosely

**Diagnosis.** The generic diagnoses is as for *Symphitoneuria* with the exception that the pronotum has the anterolateral corner scarcely extended, if at all, and the anterior margin only slightly scalloped.

**Description.** Antennae long, about half width of frontoclypeal apotome at anterior margin; labrum without secondary setae; mandibles short and wide, teeth grouped around central concavity, similar to Figure 3B; left mandible with 2 short setal brushes in central concavity; ventral apotome moderately long and narrow; without secondary lines of weakness on head; pronotum with anterior margin only slightly scalloped if at all, anterolateral corner either rounded or with very small projection; foretrochantin sinuous, long tapering; metanotum with 4 comparatively small sclerites; metasternum with 12-59 setae, some with small pale basal sclerite; hind tibia divided; gills single filaments; lateral line starts anteriorly on segment III; tergite IX

with 6 long and 4 short setae; anal prolegs without secondary setae.

**Remarks.** There are two other species in this genus, both from New Zealand. Larvae of only one is known belonging to the recently described *T. mosely* (McFarlane & Ward, 1990). The larvae of this species fit the above generic description (Cowley, 1978, as *T. oreolimnetes*).

### *Triplectidina nigricornis* Mosely

Figs 8, 24H

**Material examined.** Twenty reared males, 20 reared females and 144 larvae. VICTORIA: Billabong of Werribee River, 15 km north-west of Ballan, 15 Nov. 1985, 14; Lerderderg River, 4.8 km west-north-west Blackwood, 13 Sept. 1983, 1; Lerderderg River, 3.8 km north-north-west of Blackwood, 15 Nov. 1985, 4; Swamp at Bullarto, 12 Oct. 1983, 9 males (PT-948), 6 females, 24 (incl. PT-952); pond beside Acheron River, 3 km north-north-east of Narbethong, 16 Oct. 1981, 8 males, 8 females, 28, 15 Mar. 1983, 41; temporary tributary of the Acheron River, 12 km north of Warburton, 22 Oct. 1982, 25; pond beside Moroka River, 10 km east of Mount Wellington, 7 Nov. 1984, 3 males, 6 females, 7.

**Description.** *Head.* Width 0.70-0.88 mm (n=68, 5 sites); oblong dorsally; dark brown with weakly contrasting orange spots, sometimes pale area on frontoclypeal apotome at constriction on each side; frontoclypeal apotome widest on anterior margin, rounded and tapering behind constriction; ventral apotome tapering fairly strongly, posterior width less than half the anterior width; left mandible with 6 teeth, right mandible with 6 teeth.

*Thorax.* Pronotum brown with yellow spots posteriorly; mesonotum mottled orange and brown with pale to dark yellow spots; metanotal sclerites arranged as in Figure 8, pale brown with pale yellow spots; foretrochantin with upturned tip at sharp angle to base; prosternal sclerites dark brown; mesosternal sclerites light brown with brown anterior margin; legs without pigment bands; foreleg pale brown, midlegs orange, hindlegs yellow, all with coxae darker and with pale yellow spots.

*Abdomen.* Lateral hump sclerites pale yellow with a pale brown stem; gills as in diagram in table 1; tergite IX pale brown, often with very pale patch posteriorly at each end; lateral sclerite and ventral sole plate pale brown; anal claw moderately large, with 2, rarely 3, nearly parallel accessory hooks on outer margin.

*Body length.* 6-10 mm.

*Case.* Commonly made of comparatively heavy pieces of old detritus including leaves, bark, and stems all cut into rounded, square or rectangular pieces that are placed together to form slightly tapering tube (Fig. 24H), often with 3 or 4 pieces of detritus along top and bottom and many smaller pieces along sides. Rarely case made of spirally arranged wattle (*Acacia*) pinnules or hollowed twig. The case varies from only slightly longer than larva to about twice as long, most commonly around one and

one half times length of larva.

*Early instar larvae.* The character states described above are present in fourth and third instar larvae although more difficult to see. Head widths: fourth instar 0.45-0.60 mm (n=36, 4 sites), third instar 0.31-0.39 mm (n=34, 3 sites).

**Habitat and distribution.** Larvae are found associated with detritus in temporary swamps, pools filled by flooding streams and slow flowing areas of temporary streams. The known distribution of Tasmania, central and western provinces and Victoria, Gippsland (Neboiss, 1983) is here extended to include central and more of eastern Victoria.

### *Triplectides* Kolenati

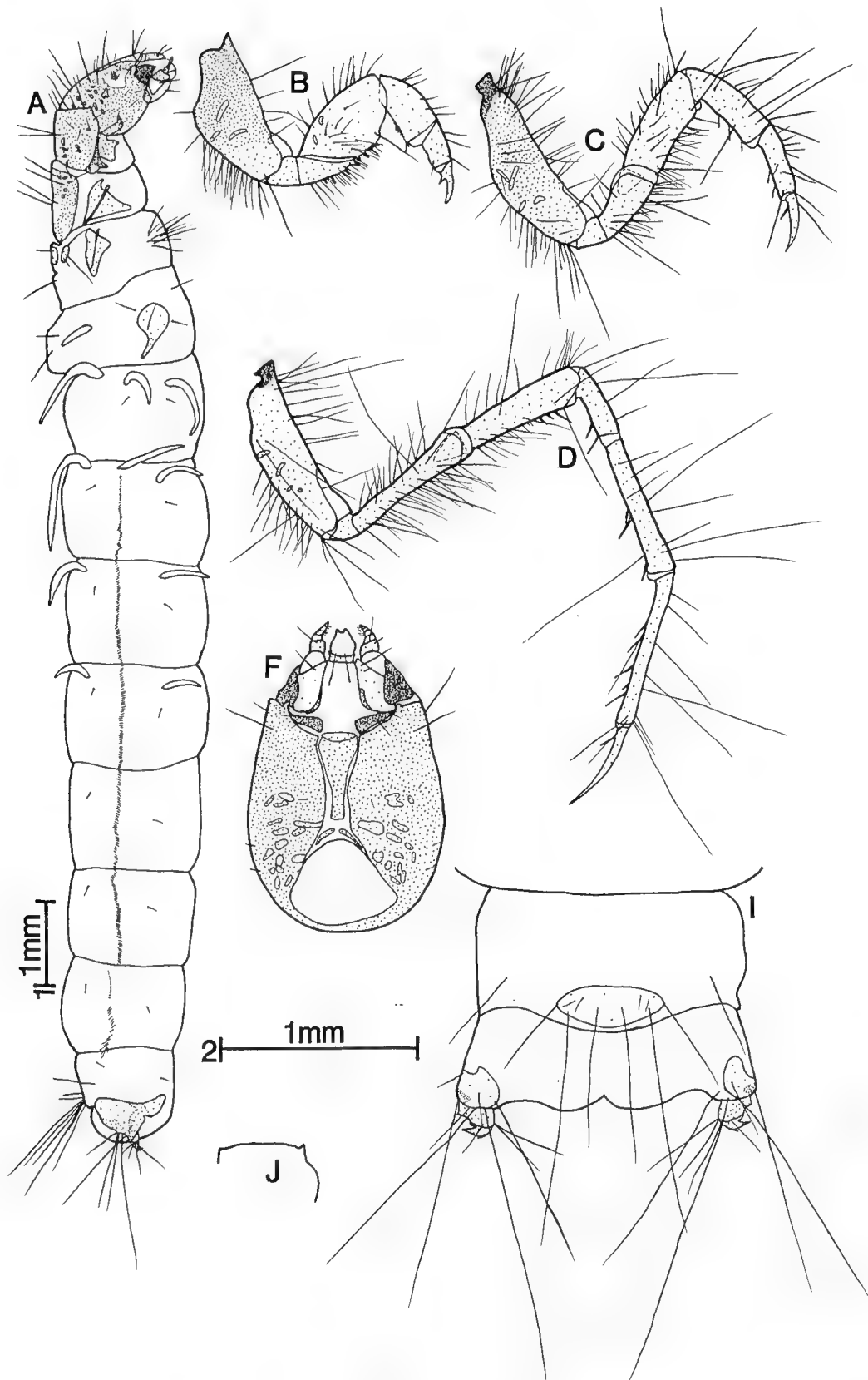
**Diagnosis.** This genus can readily be identified by the combination of short antennae and pronotum with projections on the anterior margin.

**Description.** Antennae (not including terminal hair-like segment) short, usually about one-eighth the width of the frontoclypeal apotome at anterior margin; labrum without secondary setae; mandibles short and broad, teeth grouped around central concavity, similar to Figure 3B, some more slender; left mandible with 2 short setal brushes in central concavity; ventral apotome long and narrow or moderately thick, tapering to variable degree; without secondary lines of weakness on head; pronotum anterolateral corner with at least small projections, anterior margin at least lightly scalloped; foretrochantin sinuous, long tapering; metanotum with 4 or 5 sclerites (some or all may be pale); metasternum with 3-100 setae, associated with none to 4 sclerites, and some small additional sclerites on some specimens; hind tibia divided (except in *T. varius*); gills single or multiple filaments; lateral line starting anteriorly on segment III; tergite IX with 6 long and 4 short setae; anal prolegs without secondary setae.

**Remarks.** Larvae of the Australian species fit the generic diagnosis of Holzenthal (1988a) based on the South American species, with one exception: some Australian species have a sclerite on the metanotum at sa2 and Holzenthal states there are none in this position.

This genus is the most widespread in the subfamily, found in Asia as far North as Japan, New Guinea, South Pacific Islands (including Vanuatu, New Caledonia and New Zealand) and South and Central America as well as Australia (Morse & Neboiss, 1982). The Australian species were revised by Morse & Neboiss, (1982) and, incorporating a new synonymy, the number of Australian species is 24. As a result of collecting and rearing during this study, larvae of 11 species are described here, ten for the first time.

Larval *Triplectides* are common and widespread. They occur in a variety of water bodies from sphagnum bogs at high altitudes to temporary swamps in lowland areas.



**Fig. 8.** *Triplectidina nigricornis* larva (PT-952). A – body lateral view, B – right foreleg, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner. A – scale 1, B-J – scale 2.

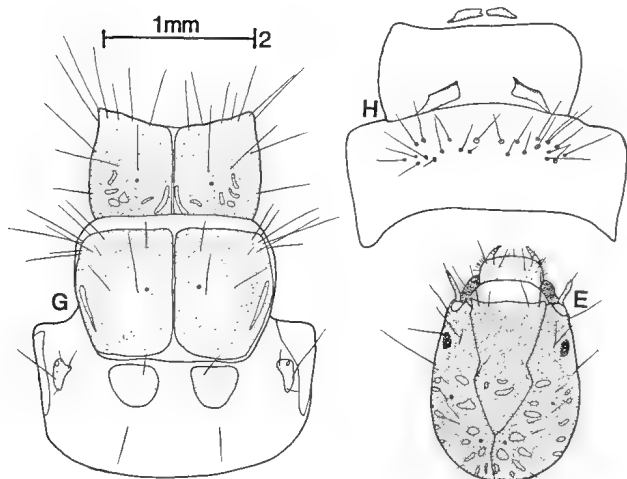


Fig. 8 cont'd.

Up to three species have been found at one site on many occasions. The larvae are amongst the largest in the family.

Larvae of this genus have a variety of case types. Although some species make a characteristic case, larvae of all *Triplectides* species will hollow out a stem or a twig. The hollowed stem or twig case is almost exclusively used by *Triplectides* larvae (only on rare occasions have larvae of *Triplectidina nigricornis* and *Lectrides varians* used such cases) and allows quick recognition of larvae belonging to this genus in the field.

Morse & Neboiss (1982) divided the Australian species into eight species groups. Larvae belonging to six of these groups were reared. Comparison of the groups is not attempted at this stage, with so few species in some groups known in the larval stage and larvae of some groups unknown. However, the early indications suggest the species groups are useful for the larval stages and so they are included below.

### Key to Species of the Genus *Triplectides*

1. Most gills divided into 2-4 filaments (Fig. 9) ..... *T. similis*  
 — Gills single filaments ..... 2
2. Metanotum with 5 sclerites (may be very pale), frontoclypeal apotome widest on anterior margin of head (Fig. 10) ..... 3  
 — Metanotum with 4 sclerites, frontoclypeal apotome as wide or wider behind its constriction (Figs 16,17) ..... 7
3. Anterolateral corners of pronotum much extended (Fig. 11) ..... 4  
 — Anterolateral corners of pronotum not extended but some may have projections on the anterior margins with larger projections on the anterolateral corners ..... 5
4. Hind tibia divided (Fig. 11) ..... *T. elongatus*  
 — Hind tibia undivided (Fig. 12) ..... *T. varius*
5. Two comparatively large pale sclerites present on metasternum; mesonotum a very pale yellow and hard to see, in contrast to very dark pronotum (Fig. 10) ..... *T. proximus*  
 — Four small sclerites on metasternum; mesonotum mottled brown, paler than pronotum but not strongly contrasting (Figs 13, 14) ..... 6
6. Ventral apotome very narrow posteriorly; frontoclypeal apotome with a large pale patch on each side at constriction; legs without dark pigment bands; case rarely much wider than larva (Fig. 13) ..... *T. truncatus*  
 — Ventral apotome little narrower posteriorly than anteriorly; frontoclypeal apotome without large pale patches at constriction; legs sometimes with dark pigment bands; case often many times wider than larva (Fig. 14) ..... *T. altenogus*

7. Frontoclypeal apotome wider behind constriction than on anterior margin; usually irregular shape behind constriction (Fig. 15) ..... *T. australicus* group\*
- Frontoclypeal apotome as wide behind constriction as on anterior margin, or if wider then pronotum with only slight scalloping on anterior margin (Fig. 17) ..... 8
8. Pronotum lightly scalloped on anterior margin; frontoclypeal apotome with at least 3 conspicuous yellow patches, 1 on each side at the constriction and 1 in the posterior tip (Fig. 17) ..... *T. australis*
- Pronotum with long projections (similar to Fig. 16J) on anterior margin; frontoclypeal apotome usually without 3 conspicuous yellow patches ..... 9
9. A conspicuous yellow patch on posterior tip of frontoclypeal apotome, other patches if present, less conspicuous; head not elongate; head and thorax brown to dark brown (Fig. 18) ..... *T. voldai*
- No conspicuous yellow patches on frontoclypeal apotome although some small spots present; head elongate; head and thorax orange (Fig. 19) ..... *T. magnus*

\*For separation of *T. australicus* and *T. ciuskus* see the descriptions of the two species.

### *T. similis* group

**Diagnosis.** Gills divided into filaments; frontoclypeal apotome widest on anterior margin; pronotum with slight scalloping and slightly larger projections on anterolateral corner; 4 metanotal sclerites; metasternum with 18-31 setae.

### *Triplectides similis* Mosely

Figs 9, 24I

**Material examined.** Fifteen reared small eyed males, 9 reared large eyed males listed below with (e) after the number of males, 40 females and 162 larvae. VICTORIA: McKenzie River at Falls, 3 km south-east of Zumsteins, 3 Nov. 1981, 1 male(e), 2 females; Mount Rosea Creek, 8 km west-south-west of Halls Gap, 3 Nov. 1981, 1 female, 3; Chapple Creek, 4 km west of Chapple Vale, 24 Oct. 1984, 2 females, 9; Gellibrand River, 5 km west of Chapple Vale, 24 Oct. 1984, 3 females, 7; Loves Creek, 7 km north of Gellibrand, 1 male, 1 male(e), 2 females; Ford River, 7 km south-east of Lavers Hill, 5 Dec. 1983, 1 male, 1 female; Barwon River, 7 km south of Winchelsea, 26 Jan. 1982, 1 female; Lake Daylesford at Daylesford, 11 Nov. 1981, 3 females; Coliban River at Trentham Falls, Trentham, 11 Nov. 1981, 1 female, 6; Yarrowee River, 4 km north-west of Inverleigh, 27 Jan. 1982, 1 male(e); Werribee River, 15 km north-north-west of Ballan, 25 Nov. 1982, 1 male(e), 1 female, 29 June 1982, 1 male(e); Lerderberg River, 4.8 km west-north-west of Blackwood, 15 Oct. 1984, 1 male (incl. PT-944); Balcombe Creek, beside Balcombe Army Camp, Nepean Highway, Mornington, 23 Dec. 1984, 1 female; Woori Yallock Creek, 6 km west of Yarra Junction, 16 Oct. 1981, 1 female; Acheron River, 5 km west-south-west of Marysville, 19 Oct. 1984, 1 male(e); Acheron

River, 3 km south of Taggerty, 19 Oct. 1984, 1 female; Acheron River at Taggerty, 18 Oct. 1984, 1 female, 20; Acheron River at Acheron, 30 Jan. 1982, 1 female; Big River, 10 km south-west of Jamieson, 30 Jan. 1982, 1 male(e), 1 female; La Trobe River at Hawthorn Creek, 12 km east of Neerim, 27 Oct. 1981, 1 male(e); Lower Tanjil River on Moe to Erica Road, 26 Oct. 1981, 1 male(e); Stony Creek at Cheshunt, 2 Oct. 1982, 1 males(e), 3 females; Dandongadale River, 3 km west of Dandongadale, 2 Oct. 1982, 2 females, 8; Ovens River at Porepunkah, 2 Oct. 1982, 1 male(e); Macalister River, 15 km south-south-east of Licola, 7 Nov. 1984, 3 females; Wonangatta River at Waterford, 14 Nov. 1983, 1 female, 8 Nov. 1984, 2 males, 2 females, 47 (incl PT-942); Tambo River, 17 km south-east of Omeo, 30 Sept. 1982, 4 males, 8; Rocky River, 17 km north-east of Orbost, 14 Oct. 1982, 4 males(e), 2 females, 50; Rich River, 26 km north-north-east of Orbost, 13 Oct. 1982, 14; Tonghi Creek on Princes Highway, 13 Oct. 1982, 1 male(e), 4 Jan. 1982, 1 female; Thurra River on Princes Highway, 3 Jan. 1982, 1 female; Bemm River on Princes Highway, East Gippsland, 14 Oct. 1982, 1 female; Wingan River on Princes Highway, 3 Jan. 1982, 1 female; Betka River, 11 km west-south-west of Mallacoota, 6 July 1983, 4. NEW SOUTH WALES: Little Henry River, 17 km south-east of Glen Innes, 20 May 1983, 1 female, 3; Back Creek, 16 km south-east of Glen Innes, 20 May 1983, 1 male.

**Diagnosis.** This species is readily recognised by the divided gills. The rounded head shape, pale head colour, shape of pronotum anterior margin and corner, and case type are also useful in recognition.

**Description.** *Head.* Width 1.00-1.22 mm (n=87, 14 sites); oblong but somewhat rounded dorsally; usually orange to orange-brown, rarely brown, with comparatively large contrasting yellow spots; yellow patch on each side of frontoclypeal apotome at constriction, sometimes extending to anterior margin; frontoclypeal apotome

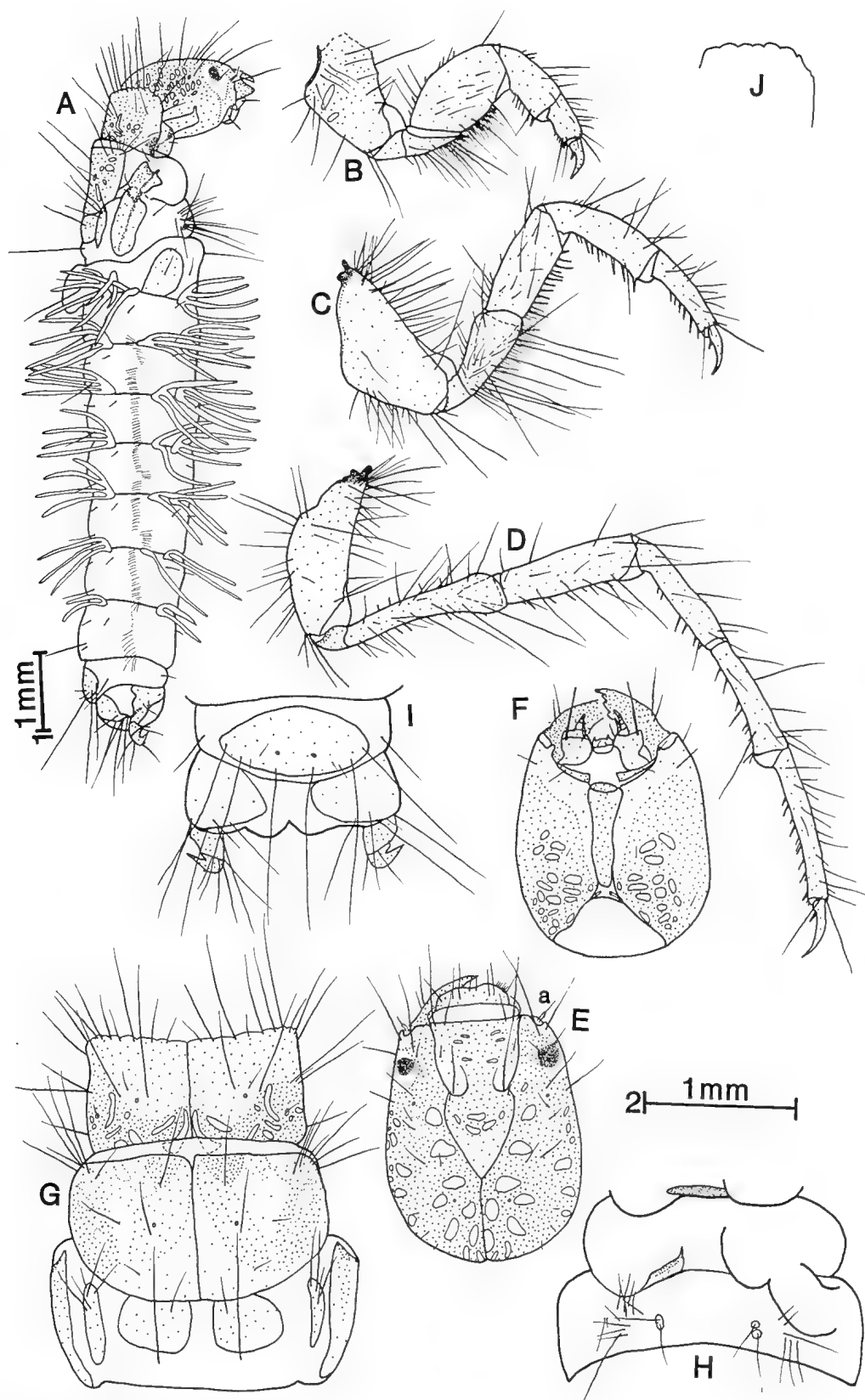


Fig. 9. *Triplectides similis* larva (PT-942). A - body lateral view, B - right foreleg, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - thorax ventral view, I - segment IX dorsal view, J - right anterolateral pronotum corner. A - scale 1, B-J - scale 2. a - antenna.



sometimes pale posteriorly; some with pale stripe posterodorsally on each side; pale patch around eye nearly straight on posterior margin; frontoclypeal apotome widest on anterior margin, rounded and tapering behind constriction; ventral apotome tapering posteriorly, rarely broad for most of length; left mandible with 7 teeth; right mandible with 5 teeth.

**Thorax.** Pronotum yellow-brown with contrasting yellow spots; anterior margin lightly scalloped with slightly larger projections on anterolateral corners, rarely almost straight margin with corners almost rounded; mesonotum mottled pale brown with lightly contrasting yellow, rarely very pale yellow, patches; usually with brown patch on anterior margin at midline; metanotum with 4 sclerites arranged as in Figure 9, medial sclerites pale yellow-brown, lateral sclerites paler yellow brown; with 18-31 metasternal setae, most associated with 2-4 small pale sclerites, those not associated with these sclerites sometimes with very small pale basal sclerite; foretrochantin with upturned section short; prosternal sclerite dark brown, comparatively broad; mesosternal sclerites pale yellow with orange anterior margins; legs as in Figure 9B-D with or without pigment bands; hind tibiae divided.

**Abdomen.** Lateral hump sclerite pale yellow, slightly darker anteriorly; number of gill filaments highly variable even at one site, at least some divided with up to 4 filaments, usually more anterodorsally, some of range shown in diagram in table 1; tergite IX pale orange, lateral sclerite and ventral sole plate pale orange; anal claw moderately large with one accessory hook on outer margin.

**Body length.** 6-14 mm, possibly some increase in size with warmer water.

**Case.** A hollowed twig or distinctive curved case made of numerous small pieces of detritus, mainly wood or stem (Fig. 24I). Distinctive case is used by all early instar larvae, hollowed twig not used until third instar or later. Case usually not much longer than larva, rarely up to twice as long. Nearly all cases cause larvae to float on the water's surface.

**Early instar larvae.** Fourth instar larvae are little different to fifth instar and so readily recognisable; head width 0.66-0.80 mm (n=23, 6 sites). Third instar larvae have several anterior gills divided into at least 2 filaments; head width 0.44-0.50 (n=14, 4 sites). Earlier instar larvae can often be identified from their distinctive case.

**Remarks.** Morse & Neboiss (1982) note that there are large and small eyed males in this species. No obvious larval differences appeared to occur that could be related to eye size of males. Males of both eye types were reared during this study and both types from the one locality on one occasion.

**Habitat and distribution.** This species is found in a wide range of flowing habitats, from cool alpine creeks to cool forested creeks to warm lowland rivers. Usually year round flow is required but rarely it is found in

streams that do not flow in summer. Three pupae collected from one stick in Lake Daylesford, Victoria may have washed in from an inflow creek. Most larvae collected were near the surface on macrophytes, wood and submerged riparian vegetation. Larvae hatched from eggs in the laboratory swam almost constantly whilst larvae of the other species hatched from eggs, *T. truncatus*, *T. ciuskus* and *T. proximus*, did not swim at all. The *T. similis* hatchlings may swim to riparian vegetation. Kept in still water in the laboratory, many larvae of this species crawled out of their containers, whilst those of *T. truncatus* and *T. ciuskus* did not. Neboiss (1983) gives the distribution as south-east Queensland, New South Wales, Victoria, South Australia, and Tasmania.

### *T. proximus* group

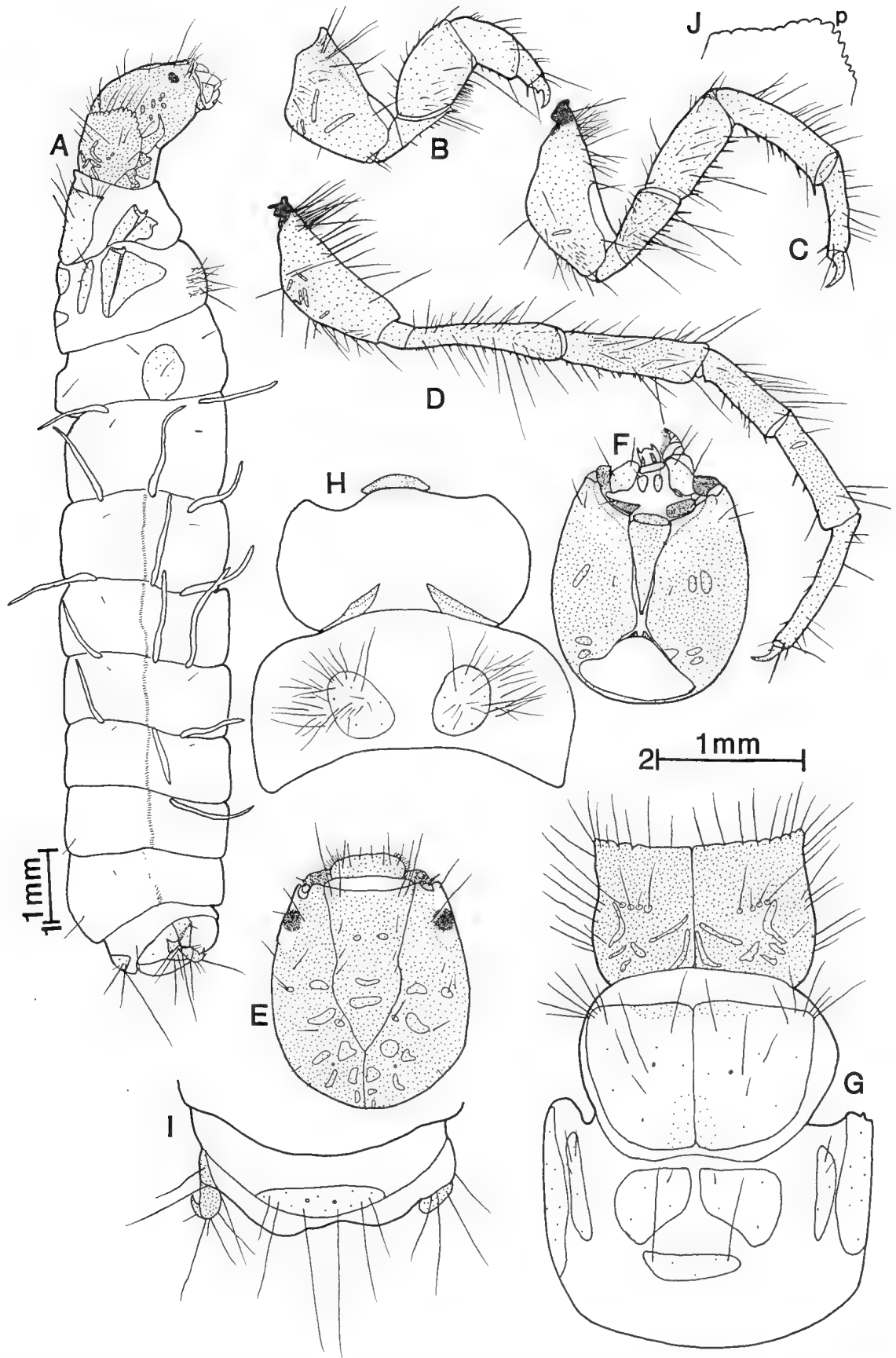
Larvae of only one of the two species from this group are described here.

**Diagnosis.** Frontoclypeal apotome widest on anterior margin; pronotum with only small projections and these extending laterally; metanotum with 5 sclerites; 24-61 metasternal setae and 2 comparatively large pale sclerites.

### *Triplectides proximus* Neboiss

Figs 10, 24J

**Material examined.** Eleven reared males, 16 reared females and 188 larvae. VICTORIA: Murrundindi River, 2 km west-south-west of Buxton, 11 Feb. 1984, 6; Big Pats Creek, 4 km east-south-east of Warburton, 6 Nov. 1983, 3 females, 19; Acheron River, 12 km north of Warburton, 8 Mar. 1981, 1 female, 16 Oct. 1982, 1; Acheron River, 3.5 km east-south-east of Narberthong, 17 July 1981, 2 males, 5 females, 16 Oct. 1981, 2 males, 2 females; Acheron River at Taggerty, 19 Oct. 1984, 18 (incl. PT-941); Toorong River, 5 km north-east of Noojee, 24 July 1981, 2 males; Toorong River, 6 km north-east of Noojee, 27 Nov. 1981, 12; Loch Creek on Loch Valley Road, first crossing north of Noojee, 24 July 1981, 1 female, 2; Western Tyers River, 18 km north-north-east of Erica, 28 Oct. 1981, 2 females, 10; Middle Tyers River, 3.5 km north-north-east of Erica, 27 Oct. 1981, 1 male; Eastern Tyers River, 3.5 km north-north-east of Erica, 27 Oct. 1981, 1 male, 2 females, 2; Howqua River, 18 km south-east of Merrijig, 31 Jan. 1982, 3; Delatite River, 2 km south of Merrijig, 8 Nov. 1981, C. Yule, 1 male; Macalister River, 5 km south of Mount Howitt, 18 Nov. 1985, 4; Two Mile Creek, 6 km north of Dargo, 8 Nov. 1984, 4; Tarra Falls approximately 12 km north-west of Yarram, 9 Dec. 1984, 2 males (incl. PT-892); Bundarra River, 16 km north-west of Omeo, 1 Oct. 1982, 1; Mitta Mitta River at Glen Valley, 30 Sept. 1982, 15; Snowy Creek, 8 km south-east of Mitta Mitta, 30 Oct. 1982, 11; Maroka River, 10 km east of Mount Wellington, 7 Nov. 1984, 1; Rodger River, 23 km south-west of Bonang, 1 Nov. 1983, 13; Ada River, 4 km south-south-west of Errinundra, 27 Jan. 1983, 21; West Errinundra River, 4 km north-north-west of Errinundra 30 Dec. 1983, 12; West Errinundra River, 5 km



**Fig. 10.** *Triplectides proximus* larva (PT-941). A – body lateral view, B – right foreleg, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner. A – scale 1, B-J – scale 2. p – projection.

north-north-west of Errinundra, 31 Dec. 1983, 12; Errinundra River, at junction with Ada River, East Gippsland, 27 Jan. 1983, 15; East Branch of East Errinundra River, approximately 23 km south-east of Bonang, 26 Jan. 1983, 13.

**Diagnosis.** As well as the character states listed in the species group diagnosis, this species is recognised by the mesonotum being much paler than pronotum.

**Description.** *Head.* Width 0.85-1.32 mm (n=880, 5 sites); rounded dorsally; red-brown or very dark, almost black, with only lightly contrasting orange spots, only small spots on frontoclypeal apotome; pale patch around eye with curved posterior margin; frontoclypeal apotome widest on anterior margin, rounded and tapering behind constriction; ventral apotome tapering to point posteriorly; left mandible with 5 or 6 teeth; right mandible with 4 teeth.

*Thorax.* Pronotum red-brown to dark brown with only lightly contrasting orange spots, anterolateral corner with several small fairly regular projections extending onto lateral margin, anterior margin very lightly scalloped; mesonotum usually pale yellow, with small brown patch on anterior margin of each sclerite, very much paler than pronotum; metanotal sclerites pale yellow, can be difficult to see, 5 sclerites arranged as in Figure 10 (posterior medial sclerite may be difficult to see); foretrochantin stout basally with upturned section narrow; prosternal sclerite brown; mesosternal sclerites pale brown with darker anterior margin, metasternal setae very numerous, 24-61, less than half associated with 2 comparatively large pale medial sclerites; legs brown, some with lightly contrasting spots, without pigment bands although joints may be paler than rest; hind tibia divided.

*Abdomen.* Lateral hump sclerite yellow posteriorly, pale brown anteriorly; gills single filaments, arranged as in diagram in table 1, maximum number the most common; tergite IX pale brown or yellow, may be difficult to see; lateral sclerite and ventral sole plate very pale brown; anal claw with 3 accessory hooks on outer margin, each decreasing in size so that sometimes only one is clearly visible.

*Body length.* 5-16 mm.

*Case.* A hollowed twig or piece of charcoal (Fig. 24J). Small pieces of detritus occasionally added around entrance to stick and case may be extended posteriorly using small pieces of detritus. Case usually one and one-half to 2 times length of larva. Virtually all early instar larvae use sand cases made by other trichopteran larvae. Such 'borrowed' cases are generally recognisable as belonging to *Triplectides* larvae due to their habit of adding detritus to front of case. Most larvae change to hollowed stick case during their third or fourth instar.

*Early instar larvae.* Head shape and very much paler mesonotum make this species identifiable in third or earlier instars. Head width ranges at Acheron River were: fourth instar 0.63-0.85 mm, third instar 0.37-0.56 mm, second instar 0.25-0.31 mm, and first instar 0.16-0.18 mm.

**Habitat and distribution.** Larvae are found in backwaters and log jams in montane and foothills rivers and creeks, and are apparently confined to cool waters. Neboiss (1983), lists the distribution as New South Wales; Victoria, south-east coastal ranges; Tasmania, northern provinces. Collections for this study were made in most of eastern and central Victoria and no further west than Mount Macedon where a male pupa, lodged in the Museum of Victoria, was found.

### *T. elongatus* group

Larvae of only two of the six species in this group are known, *T. elongatus* and *T. varius*.

**Diagnosis.** Frontoclypeal apotome widest on anterior margin; pronotum anterolateral corner much extended; 5 metanotal sclerites; metasternum with 26-100 setae; comparatively short hindlegs (tibia undivided in *T. varius*).

### *Triplectides elongatus* Banks

Fig. 11

**Material examined.** 27 reared males, 32 reared females and 93 larvae. VICTORIA: Headwaters of McFarlane Creek, 4 km west of Mount Wellington, 6 Nov. 1984, 1 male, 5 females, 19 (incl. PT-945); Lake Mountain, swamp on creek at Snowy Hill Car Park, 18 Nov. 1983, 14 males (incl. PT-929), 12 females, 36; headwaters of Caledonia River, near Howitt Hut, Howitt Plains, 18 Nov. 1985, 4; Mount Baw Baw, sphagnum bog 400 m east of Baw Baw Alpine Village, 9 Dec. 1983, 4 males, 4 females, 7; Mount Buffalo, small creek 300 m south-east of Tatra Inn, 6 Dec. 1982, 1 male, 4 females, 5, 27 Nov. 1983, 6 males, 7 females, 8; Mount Buffalo, head of Bunyip River, I. Bayly & J. McAuley 28 Oct. 1978, 14; small tributary of Rocky Valley Dam 3 km north-north-east of Mount Cope, 1 Oct. 1982, 1 male.

**Diagnosis.** The character states listed for the *elongatus* group are distinctive of both known species. Apart from the undivided tibia of *T. varius*, the larvae of this species and *T. elongatus* are very similar. *T. elongatus* larvae generally have fewer metasternal setae, frontoclypeal apotome with the constriction more rounded, pronotum anterolateral corner more extended, extended laterally as well as anteriorly and anterior margin more lightly scalloped. However overlap occurs in all characters other than division of the tibia:

Third instar larvae are more difficult to distinguish from other species due to the rounded pronotum but the hind tibia is still divided, readily distinguishing it from *T. varius* the only species in the genus it has been found to co-exist with to date.

**Description.** *Head.* Width 1.08-1.23 mm (n=27, 3 sites); rounded dorsally; dark brown to black with lightly

contrasting orange spots, only small spots on frontoclypeal apotome; some larvae with head pale posteriorly; pale patch around eye with rounded posterior margin; frontoclypeal apotome widest on anterior margin, rounded and tapering behind constriction; ventral apotome

tapered but still comparatively broad posteriorly; left mandible with 6 teeth; right mandible with 6 teeth.

*Thorax.* Pronotum dark brown with lightly contrasting orange spots, anterolateral corner extended but without projections, anterior margin lightly scalloped; metanotum

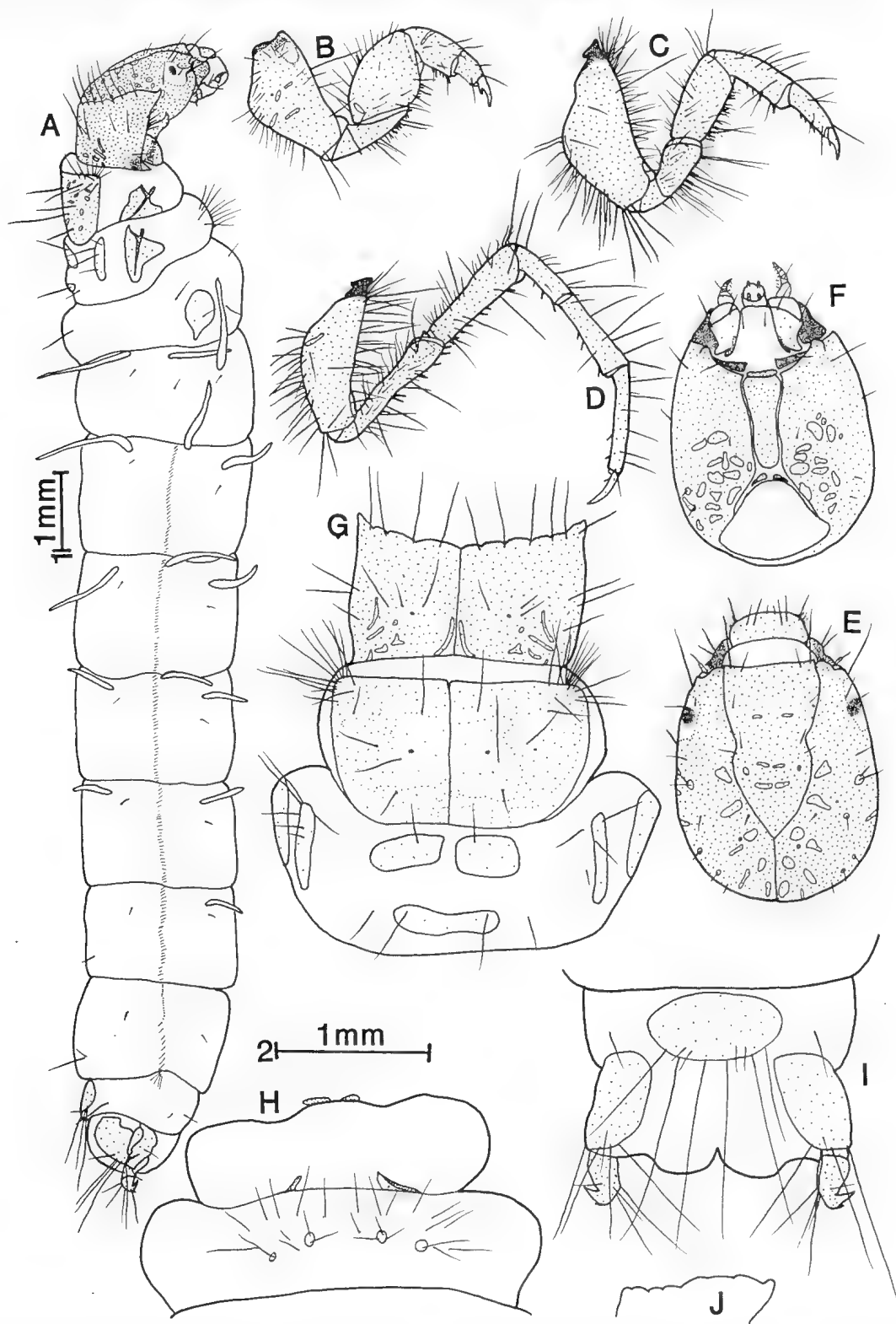


Fig. 11. *Triplectides elongatus* larva (PT-945). A - body lateral view, B - right foreleg, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - thorax ventral view, I - segment IX dorsal view, J - right anterolateral pronotum corner. A - scale 1, B-J - scale 2.

with sclerites as shown in Figure 11, anterior medial sclerites pale brown, lateral sclerites and posterior medial sclerite pale yellow; mesonotum yellow to pale brown, mottled and with lightly contrasting yellow spots; metanotum with 5 sclerites as in Figure 11 (posterior sclerite may be difficult to see); foretrochantin broad and stout basally, upturned section short and blunt; prosternum with 2 dark brown sclerites, these sometimes appearing as one; mesonotal sclerites pale brown with darker anterior margins; 26-50 metasternal setae, some associated with 4 small very pale sclerites that may be difficult to see, other setae may have small sclerite at base; legs orange-brown, without dark pigment bands; hind tibia divided.

**Abdomen.** Lateral hump sclerite yellow-orange, darker anteriorly; gills single filaments, arranged as in diagrams in table 1; tergite IX orange or pale brown; lateral sclerites and ventral sole plate orange; anal claw large, with one accessory hook on outer margin.

**Body length.** 9-13 mm.

**Case.** Construction appears variable at different localities probably due to availability of materials. Dorsal surface always longer than ventral so that short hood formed. Case usually tubular, tapering posteriorly and little longer than larva. Case types: (i) hollowed twig or rush stem, (ii) several narrow twigs or rush stems bundled together in a similar manner to Figure 24N, (iii) several rectangular pieces of detritus resulting in a case similar to that of *Triplectidina nigricornis* (Fig. 24H) or (iv) numerous very small pieces of detritus. Sand grains used with small pieces of detritus but mostly by early instar larvae. Many larvae add thin short stems to extend out like skirt. If hollowed twig used, little detritus may be added to anterior end and some to posterior end to lengthen case.

**Early instar larvae.** Fourth instar larvae, head width 0.58-0.75 mm (n=11, 2 sites), are recognisable from above characters. Third instar larvae, head width 0.38-0.41 mm (n=3), have pronotum anterolateral corner rounded and hind tibia divided.

**Habitat and distribution.** Larvae have been found only in sphagnum bogs and small alpine creeks above about 1500 m in altitude. Collection of larvae from very shallow water following heavy rain suggests they are able to survive drying of surface water, presumably in damp moss or buried in gravel.

The distribution listed in Neboiss (1983) of eastern New South Wales, north-east Victoria, and Tasmania does not mention altitude, possibly because adults are capable of long distance flight.

### *Triplectides varius* Kimmins

Figs 12, 24K

**Material examined.** Twelve reared males, 12 reared females and 17 larvae. VICTORIA: Mount Baw Baw, small creek approximately 400 m east of Baw Baw Alpine

Village, 9 Dec. 1982, 11 males, 12 females, 15 (incl. PT-938); small creek in snowgrass plain 4 km north of Mount Wellington, 6 Jan. 1984, 1 male; Mount Buffalo, pool in swamp at head of Bunyip River, I. Bayly & J. McAuley, 28 Oct. 1978, 2. NEW SOUTH WALES: small tributary of Lake Albina approximately 20 m upstream of lake, 22 Feb. 1983, 6 males, 4 females, 15; Sphagnum bogs 3.5 km west-south-west of Guthega (approximately 1680 m altitude), 22 Feb. 1983, 8 males, 3 females, 6; small creek on Drift Hill approximately 5 km east-south-east of Thredbo, 20 Nov. 1982, 3 males (incl. PT-956), 8 females, 3; Geehi River on slopes of Mount Jagungal, L. Metzeling, 4 Dec. 1981, 1.

**Diagnosis.** This species is unique within the *Triplectides* in having the hind tibia undivided, otherwise it is very similar to *T. elongatus* (see Diagnosis section for *T. elongatus*).

**Description.** **Head.** Width 1.06-1.23 mm (n=29, 4 sites), rounded dorsally, dark brown to black, some specimens with very lightly contrasting orange spots, back of head paler on some, only small spots on frontoclypeal apotome, pale patch around eye with rounded posterior margin; frontoclypeal apotome widest on anterior margin, tapering behind constriction; ventral apotome tapered but still fairly broad posteriorly; left mandible with 6 teeth; right mandible with 6, rarely 5, teeth.

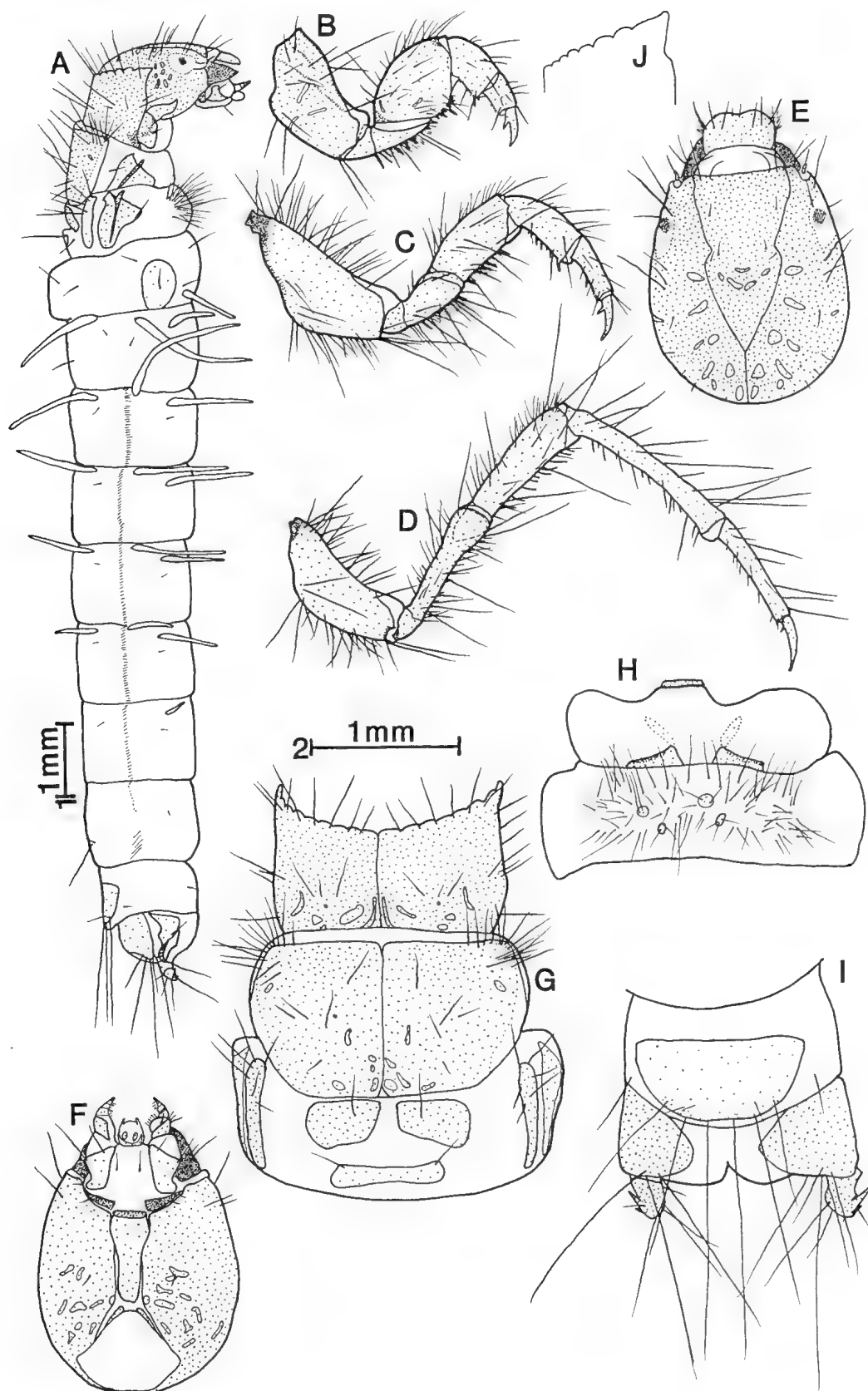
**Thorax.** Pronotum brown to dark brown, some specimens with lightly contrasting orange spots, anterior margin lightly scalloped, no projections on anterolateral corner but this very extended anteriorly; mesonotum brown to dark brown, usually little paler than pronotum; metanotum with 5 sclerites (posterior medial sclerite may be difficult to see) arranged as shown in Figure 12, pale brown, posterior medial sclerite very pale brown to pale brown; foretrochantin stout basally and with moderately short thick upturned section; prosternal sclerite dark brown; mesosternal sclerites light brown with darker anterior margin; 60-100 mesosternal setae, some associated with very pale sclerites, 1-3 per sclerite; legs fairly uniform brown, without pigment bands, hind tibia undivided.

**Abdomen.** Lateral hump sclerites pale orange; gills single filaments, arranged as in diagram in table 1; tergite IX pale brown; lateral sclerites and ventral sole plate light brown; anal claws moderately large, with 1 accessory hook on outer margin.

**Body length.** 8-13 mm.

**Case.** Tubular and slightly arched, longer dorsally so short hood formed. Made of small pieces of detritus and sand irregularly arranged (Fig. 24K), rarely with larger pieces of detritus. Rarely larvae use hollowed twigs. The case usually up to about one and one-half times length of larva.

**Early instar larvae.** Fourth instar larvae (head width 0.64-0.70, n=3) are easily identified using above description. Third instar larvae (head width 0.45 mm, n=1) have pronotum corner rounded and hind tibia undivided.



**Fig. 12.** *Triplectides varius* larva (PT-938). A – body lateral view, B – right foreleg, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner. A – scale 1, B-J – scale 2.



**Habitat and distribution.** Larvae have so far only been collected from the same habitat listed for *T. elongatus*, sometimes in the same creek or bog. Collections made in very shallow water after heavy rain on two occasions suggest larvae are able to survive drying of surface water, presumably in damp moss or buried in gravel.

The current published distribution (Neboiss, 1983) is New South Wales and eastern Victoria, in the south-east mountains.

### *T. truncatus* group

Larvae of *T. truncatus* and *T. altenogus* are the only two of the seven species in this group that are known.

**Diagnosis.** Frontoclypeal apotome widest on anterior margin; pronotum with slight scalloping and small projections on the anterolateral corner; metanotum with 5 sclerites; metasternum with 8-33 setae.

### *Triplectides truncatus* Neboiss

Figs 13, 24L

*Triplectides truncatus* Neboiss 1977: 129, figs 699-702.

*Triplectides hamatus*.—Morse & Neboiss 1982: 76, figs 50, 51, 80 (new synonym).

**Material examined.** Seventy-six reared males, 88 reared females and 124 larvae. VICTORIA: Stony Creek at Turrett Falls, 3 km south-west of Halls Gap, 4 Dec. 1983, 3 males, 8 females, 5; Dairy Creek, 6 km south of Halls Gap, 3 Nov. 1981, 1 female, 1; Asplin Creek at Gellibrand River, 4 km east of Gellibrand, 26 Jan. 1982, 2 males, 2 females, 2; West Barham River, 7 km north-west of Apollo Bay, 11 Mar. 1984, 1 female, 1; Grey River, 4 km west-north-west of Kennett River township, 5 Dec. 1983, 10 males, 13 females, 34; Erskine Falls near Lorne, 25 Oct. 1984, 11 males, 5 females, 13 (incl. PT-943), 27 Jan. 1982, 1 male, 3 females; Ford River, 7 km south-east of Lavers Hill, 25 Oct. 1984, 2; Yarrowee River, 4 km north west of Inverleigh 27 Jan. 1982, 1 male; Werribee River, 15 km north-north-west of Ballan, 25 Nov. 1982, 1 male; Lerderderg River, 4.8 km west-north-west of Blackwood, 10 May 1982, A. Boulton, 1 male, 27 June 1982, Boulton, 2 males, 1 female, 23 Dec. 1982, 2 males, 4 females, 20 Jan. 1983, 1 male, 26 Feb. 1984, 2 males, 7 females, 18 Sept. 1984, 6 males, 9 females; Acheron River, 3.5 km east-south-east of Narbethong, 18 Nov. 1983, 1 female, 19 Dec. 1983, 1 male, 19 Jan. 1984, 1 male, 3 females, Acheron River, 12 km north of Warburton, 8 Mar. 1981, 1 male; tributary of the Howqua River, 18 km south-east of Merrijig, 31 Jan. 1982, 1 male, 5 females; Traralgon Creek, 4.5 km north of Calder Junction, 27 Oct. 1981, 1 male, 2 females; Western Tyers River, 18 km north-north-east of Erica, 27 Oct. 1981, 3 males (incl. PT-897), 5 females, 20; Tarra Falls approximately 12 km north-west of Yarram, 9 Dec. 1984, 8 males, 3 females, 11; Pond beside Moroka River, 10 km east of Mount Wellington, 8 Nov. 1984, 1; Dinner Creek, 15 km north-north-east of Licola, 7 Nov. 1984, 3 males, 8 females, 4; Two Mile Creek, 6 km

north of Dargo, 8 Nov. 1984, 4 males, 3 females, 2; Barkly River, 9 km north west of Licola, 18 Nov. 1985, 1 female; Eurobin Falls, Mount Buffalo National Park, 6 Dec. 1982, 11 males, 4 females, 16; Rodger River, 23 km south-west of Bonang, 2 Nov. 1983, 1 male; east branch of the East Errinundra River, approximately 23 km south-east of Bonang, 24 Jan. 1983, 12. TASMANIA: small pools on flood bank of Olga River, P.S.L., P.A. and R.S., 9 Feb. 1976, 3.

**Diagnosis.** Within the *T. truncatus* group, this species is recognisable by the frontoclypeal apotome with a yellow patch on each side at the constriction, ventral apotome very narrow in posterior half and legs without pigment bands. The case shape described above is only found in this species and can aid in identification, however, some larvae use a hollowed twig.

**Description.** *Head.* Width 0.69-0.97 mm (n=1,028, 7 sites); oblong dorsally; dark orange or brown with contrasting orange spots, some specimens with pale area on each side of head posteriorly; frontoclypeal apotome paler than surrounding area but with dark patch medially, and always with obvious yellow patch on each side at constriction, these often extending to anterior margin; pale patch around eye straight or rounded posteriorly; frontoclypeal apotome widest on anterior margin, straight sided or rounded and tapering behind constriction; ventral apotome strongly tapering so very narrow in posterior half; left mandible with 6 teeth; right mandible with 4 or 5 teeth.

*Thorax.* Pronotum brown with orange spots, anterior margin very lightly scalloped with few irregular small projections on anterolateral corner; mesonotum paler than pronotum, rarely very much so, mottled brown with orange and yellow spots; metanotum with 5 sclerites (posterior sclerite may be very pale and difficult to see), arranged as in Figure 13, medial anterior sclerites brown with yellow spots, lateral sclerites yellow and brown, posterior medial sclerite very pale yellow; foretrochantin with moderately long upturned section at fairly shallow angle to base; prosternal sclerite brown, mesosternal sclerites very pale, each with brown anterior margin, often with pale anterior extension on medial edge; 14-33 metasternal setae, mainly associated with 4 small pale sclerites, additional setae to those on sclerites may have small pale sclerite at base, up to 5 such sclerites; legs with coxae brown proximally, rest of leg segments orange, without pigment bands, fore femur with only slender dorsal spines, hind tibia divided.

*Abdomen.* Lateral hump sclerite yellow; gills with single filaments, arranged as in diagrams in table 1; tergite IX pale yellow, the 4 smaller setae may be difficult to see; lateral sclerite and ventral sole plate orange-yellow; anal claw moderately large with one, rarely 2, accessory hooks on outer margin.

*Body length.* 8-14 mm.

*Case.* Early instar larvae construct distinctive case made of pieces of twig and detritus placed together irregularly but fairly tidily so that case comparatively thin and compact, often somewhat triangular in cross-section.



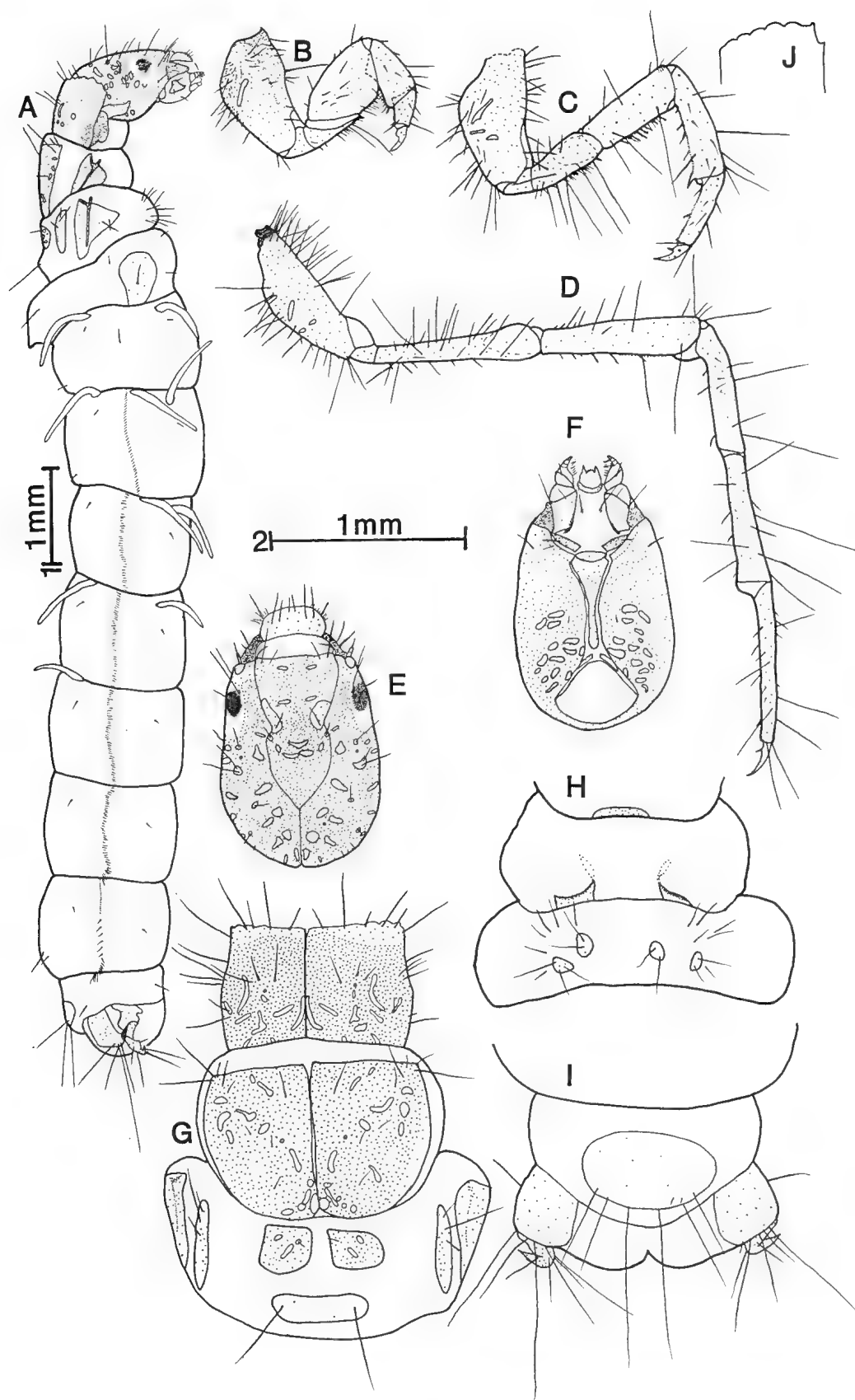


Fig. 13. *Triplectides truncatus* larva (PT-943). A - body lateral view, B - right foreleg, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - thorax ventral view, I - segment IX dorsal view, J - right anterolateral pronotum corner. A - scale 1, B-J - scale 2.

Late instar larvae have either case of this form or use hollowed twig. Generally case is one and one-half to 2 times length of the larvae (Fig. 24L).

**Early instar larvae.** Fourth instar larvae are recognisable from the above description, head width 0.42-0.65 mm. Third instar larvae have yellow patches present on frontoclypeal apotome at constriction, head width 0.29-0.41 mm. Second instar larval head width 0.20-0.28 mm.

**Remarks.** The adult males reared during this study were not all as described in Morse & Neboiss (1982), many had characteristics of *T. hamatus* Morse & Neboiss (1982) and others showed a wide range of variation between the two. Adults of these different forms were at times reared from larvae collected at a single locality. Although some variation occurred in the larvae, as indicated in the description above, it could not be related to different types of adults. *Triplectides truncatus* was originally described from Tasmania. Only three larvae were available from Tasmania and these fit the above description. For these reasons I consider *T. hamatus* to be a synonym of *T. truncatus*.

**Habitat and distribution.** Larvae were collected on detritus accumulations in backwaters in forested montane and foothill creeks. In eastern Victoria, the larvae appear confined to upper reaches of the creeks being replaced by *T. proximus* lower in the forested section. In western Victoria where *T. proximus* does not occur, *T. truncatus* occurs in lower, warmer reaches of creeks and even in intermittent creeks. The published distribution of *T. truncatus* is Tasmania, western province and Victoria widespread along south coast ranges (Neboiss, 1983). Larval collections and the recorded distribution of *T. hamatus* of eastern New South Wales coastal ranges pushes the distribution further north in Victoria and into New South Wales.

### *Triplectides altenogus* Morse & Neboiss

Figs 14, 24M

**Material examined.** Six reared males, 7 reared females and 40 larvae. VICTORIA: Bellbird Creek at Bellbird, East Gippsland 13 Oct. 1982, 1 male; Thurra River on Princes Highway, East Gippsland, 13 Oct. 1982, 2; Tonghi Creek on Princes Highway, East Gippsland, 13 Oct. 1982, 1; Back Creek, 1 km north-east of Noorinbee North, 13 Oct. 1982, 3 males, 3 females, 2; Rich River, 26 km north-north-east of Orbost, 14 Oct. 1982, 1 male (PT-930), 4 females; Brodribb River, 24 km north-north-east of Orbost, 14 Oct. 1982, 1 male; Martins Creek, 29 km north-north-east of Orbost, 30 Jan. 1983, 1 (PT-935); Martins Creek, 27 km south-west of Bonang, 30 Jan. 1983, 23; Rodger River, 23 km south-west of Bonang, 1 Nov. 1983, 9; east branch of East Errinundra River, approximately 23 km south-east of Bonang, 24 Jan. 1983, 1; Dowell's Creek, east branch of Mallacoota Inlet, Neboiss, 23 Mar. 1974, 1.

**Diagnosis.** Within the *T. truncatus* group, this species

and be identified by frontoclypeal apotome with only small yellow patches, if any, at the constriction, ventral apotome tapering to about half its anterior width posteriorly, forelegs with short stout spines dorsally on femur and tibia, and legs sometimes with dark bands. The case type is useful for identification unless a hollowed twig is used. The distinctive case incorporates elements of those made by *T. truncatus* and *Lectrides varians*. This species is most similar to *T. truncatus*. Third instar larvae are more difficult to distinguish from *T. truncatus* but the spines present on the foreleg and case structure are useful in identification.

**Description.** *Head.* Width 0.94-1.06 mm (n=20, 4 sites); oblong dorsally; brown to very dark brown or black with lightly contrasting orange spots, spots small on frontoclypeal apotome, pale patch around eye with straight posterior margin; frontoclypeal apotome widest on anterior margin, rounded and tapering behind constriction; ventral apotome tapering fairly strongly so posterior width about half anterior width; left mandible with 6 teeth; right mandible with 5 teeth.

*Thorax.* Pronotum brown to very dark brown or black with small lightly contrasting orange spots, very lightly scalloped and lightly serrate on anterior margin, with few small irregular projections on anterolateral corner; mesonotum paler brown than pronotum, usually with some yellow spots; metanotum with 5 sclerites (posterior sclerite may be difficult to see), arranged as in Figure 14, medial anterior sclerites brown with lightly contrasting yellow or orange spots, other metanotal sclerites pale yellow or pale brown; foretrochantin stout basally with sharply upturned tip short; prosternal sclerite dark brown; mesosternal sclerites pale brown with darker anterior margin, sometimes with pale anterior extension at medial edge; 8-15 metasternal setae, most associated with 4 sclerites, additional setae may have small sclerite at base; forelegs stout, dark brown, with short stout spines on dorsal margin, particularly on femur; midlegs and hindlegs brown, legs may have pigment bands, hind tibia divided.

*Abdomen.* Lateral hump sclerite yellow, darker anteriorly; gills with single filaments, as in diagram in table 1; tergite IX pale brown; lateral sclerite and ventral sole plate very pale yellow or brown; anal claw with 1 accessory hook on outer margin.

*Body length.* 13-15 mm.

*Case.* Hollowed twigs or case characteristic of species consisting of large leaf pieces forming top and bottom surfaces with tube of small pieces of detritus between them (Fig. 24M). Case usually very much wider (5 times or more) and longer than larva.

**Early instar larvae.** Fourth instar larvae are recognisable from the above description, head width 0.66-0.73 mm (n=12, 4 sites). Third instar larvae, head width 0.42-0.44 mm (n=3), with spines on the legs.

**Habitat and distribution.** Found in backwaters in medium to large creeks in far East Gippsland, often in rainforest areas. It is interesting to note that the

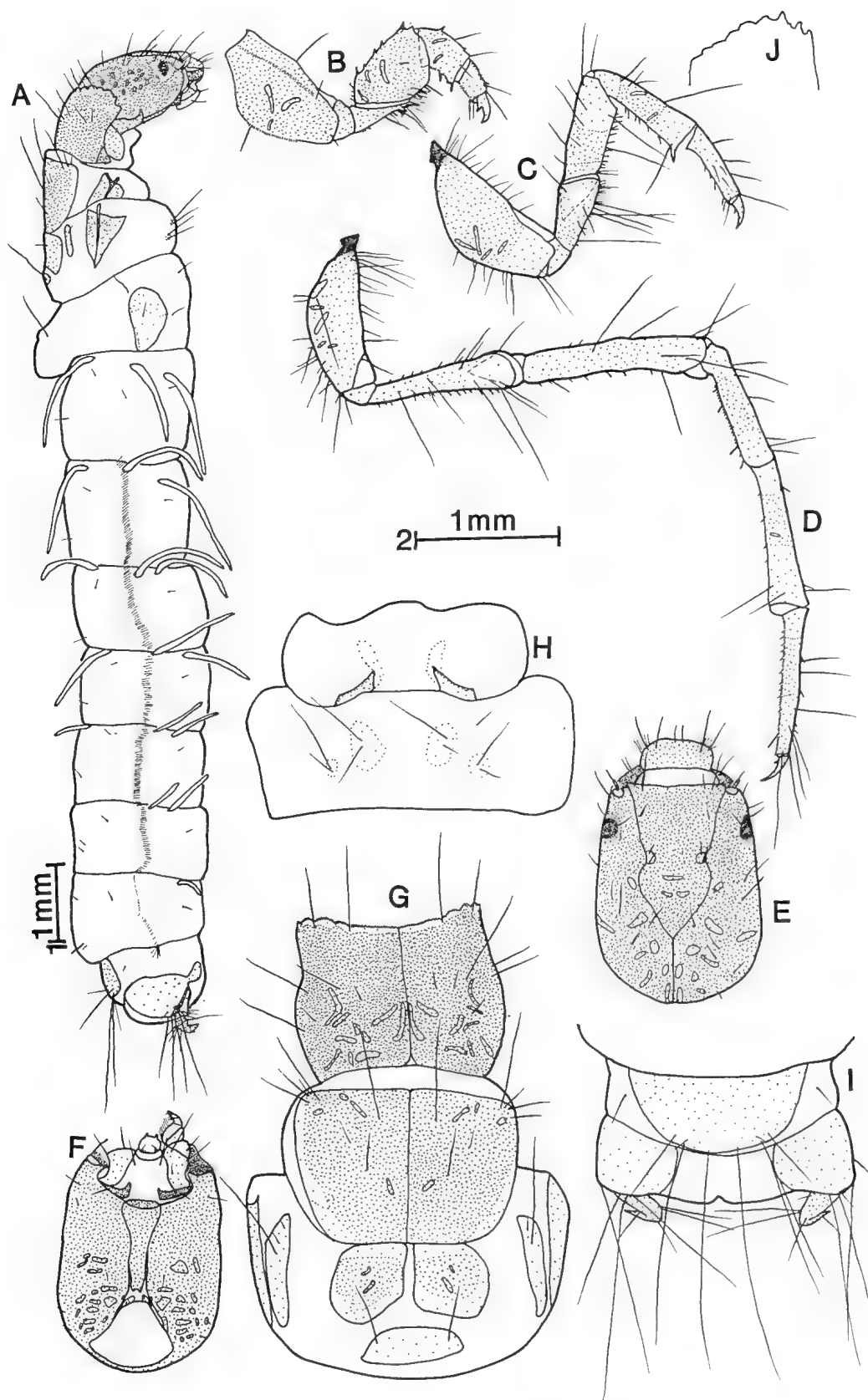


Fig. 14. *Triplectides altenogus* larva (PT-935). A – body lateral view, B – right foreleg, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner. A – scale 1, B-J – scale 2.

distribution reflects rainforest distribution in part: north-east and south-east coastal ranges of south-east Queensland, New South Wales, east Victoria (Neboiss, 1983). Larvae were also collected in lowland areas in Victoria.

### *T. australicus* group

**Diagnosis.** Frontoclypeal apotome widest behind constriction; pronotum with large projections on anterior margin; metanotum with 4 sclerites; metasternum 9-34 setae.

**Remarks.** *Triplectides australicus* and *T. ciuskus* larvae, the only two known in this group, are very similar and are sympatric. Whilst the combination of a few characters allows identification of most specimens, overlap in all characters occurs. Despite this they do appear to be distinct species. In the reared material pupae were consistently distinguishable on one character. Reared adults were instantly recognisable using spur formulae but many characters on males and females did show some overlap. Again in the reared material, *T. ciuskus* larvae always matched with the *T. ciuskus* pupal character and *T. ciuskus* adult spur formula, showing that the species differences, while small, do hold. This generally held also for *T. australicus* with the exception that a few reared larvae were similar to *T. ciuskus*. Such larvae may be mistaken for *T. ciuskus* larvae but the proportion of larvae this applies to is small.

### *Triplectides australicus* Banks

Fig. 15

**Material examined.** Nineteen reared males, 16 reared females and more than 84 larvae. VICTORIA: Floating Islands Lagoon 2.5 km west of Pirron Yallock, 24 Oct. 1984, 1 male, 1 female, 2; Pirron Yallock Creek at Pirron Yallock, 24 Oct. 1984, 1 male; Barwon River, 7 km south of Winchelsea, 26 Jan. 1982, 1 female; Mount Emu Creek at Skipton, 29 Apr. 1982, 1; Lake Daylesford at Daylesford, 11 Nov. 1981, 3 males, 12 Oct. 1983, 1 male, 3 females, 11 (incl. PT-936), 18 Sept. 1984, 5 males, 1 female, 2; Paddock Creek, 5 km west of Ballan, 10 June 1976, larvae, MV; Werribee River at Ballan, L. McMillan, 27 July 1976, larvae; Campaspe River, 5 km north-west of Woodend, 19 Nov. 1981, 3 males, 5 females, 20; 19 Oct. 1983, 2 females, 16; Broken River, 9 km north of Mansfield, 1 Feb. 1982, 5 males (incl. PT-904), 2 females, 26; Stony Creek at Cheshunt, 2 Oct. 1982, 1 female, 6; Wodonga DAW2, 18 Feb. 1970, larvae; Mitta Mitta River, Dartmouth Environmental Survey loc. AH, 30 Nov. 1973, larvae; North Melbourne, 26 Feb. 1918, M. Searle, larvae. SOUTH AUSTRALIA: Ewens Ponds approximately 13 km east-north-east of Port MacDonnell, 21 May 1984, 4 males, 2 females, 4.

**Diagnosis.** *Triplectides australicus* is sometimes indistinguishable from *T. ciuskus* larvae (see notes under

*T. australicus* group). *Triplectides australicus* larvae are usually distinguished by their orange colour and the presence of a straight line on the posterior margin of the pale patch around the eye. The following characters also usually apply: legs unbanded or with comparatively weak pigment bands; frontoclypeal apotome usually with 2 moderately large spots at the constriction, 1 on each side, rarely with a small spot in the posterior tip; knob-like extension on frontoclypeal apotome behind the constriction, if present, usually fairly small; long spots on the pronotum midline posteriorly usually indistinct in shape; spots on head may join into a large patch ventrally.

**Description.** *Head.* Width 0.84-1.13 mm (n=50, 4 sites); oblong dorsally, usually orange, some brown, with contrasting yellow spots often diffuse, frontoclypeal apotome usually with moderately large yellow patch at constriction on each side, sometimes with yellow patch in posterior tip; frontoclypeal apotome wider behind constriction than at anterior margin, shape behind constriction variable (sometimes different on 2 sides on 1 animal); with small knob at each side at widest point, straight sided then triangular, rounded or irregular; ventral apotome tapered to be about half anterior width posteriorly; pale patch around eye usually straight posteriorly but rarely with rounded posterior extension medially on one or both sides of head; larvae may be very large; left mandible with 4 teeth; right mandible with 6 teeth.

*Thorax.* Pronotum orange, rarely brown, often with diffuse yellow spots, pair of spots on midline posteriorly usually large and diffuse; pronotum with projections on anterior margin and anterolateral corners, projections truncate rectangular or more rounded, variable in size, shape and number, rarely 2 projections fuse into 1 broad one; mesonotum pale orange-brown, rarely pale brown, with diffuse yellow spots; metanotum with 4 sclerites arranged as in Figure 15, medial sclerites pale orange or brown with yellow spots, lateral sclerites sometimes paler; foretrochantin with moderately long to long, thin usually sharply upturned section; prosternal sclerite brown; mesosternal sclerites brown each with darker brown anterior margin, sometimes extended towards middle of segment on medial edge; 9-26 metasternal setae, mainly associated with 4 small pale brown sclerites, those not associated with sclerites may have very small sclerite at base; legs orange or orange-brown, with or without pigment bands, if present rarely strongly contrasting with rest of leg segment, hind tibia divided.

*Abdomen.* Lateral hump sclerite orange posteriorly, yellow anteriorly; gills single filaments, arranged as in diagram, almost all with maximum number shown; tergite IX very pale, often scarcely visible, often with variable number of pale to dark brown spots with irregular outlines in anterior third of sclerite; lateral sclerite and ventral sole plate pale, often with medial dark area with yellow spots; anal claw moderately large, with 2 or more accessory hooks on outer margin.

*Body length.* 9-18 mm, generally larger in lakes than

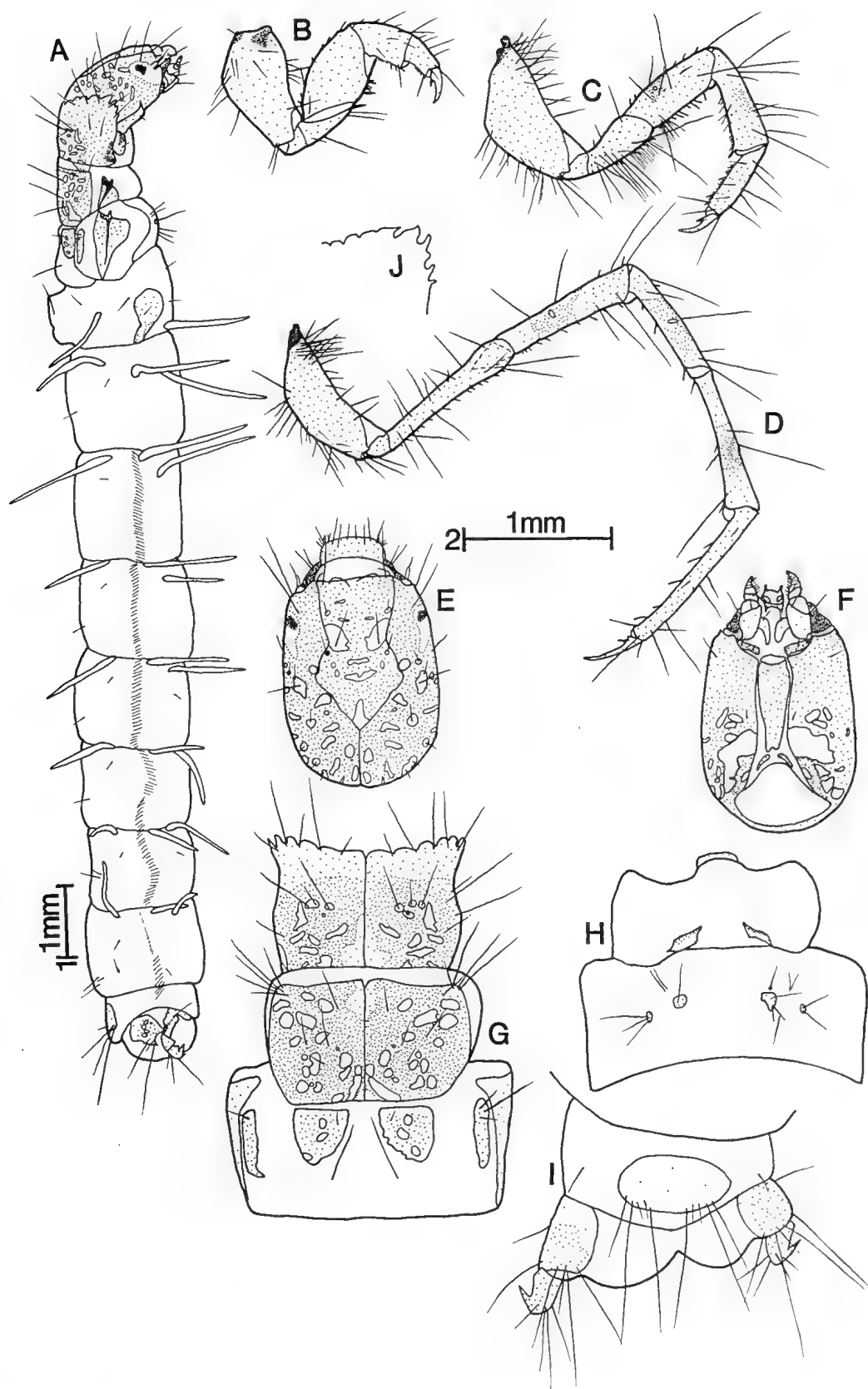


Fig. 15. *Triplectides australicus* larva (PT-936). A - body lateral view, B - right foreleg, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - thorax ventral view, I - segment IX dorsal view, J - right anterolateral pronotum corner. A - scale 1, B-J - scale 2.

in rivers.

**Case.** Case often hollowed twig or rush stem, less commonly several small stems bundled together or around main stem. Usually little or no detritus added to hollowed stick cases. Case commonly about twice length of larva, particularly in lentic habitats. The largest case found was 75 mm long by 4 mm diameter.

**Early instar larvae.** Fourth instar larvae, head width 0.53-0.69 mm (n=30, 3 sites), have the ventral apotome tapering to point and frontoclypeal apotome about same width behind constriction as at anterior margin and straight behind constriction.

**Remarks.** Larvae of this species may be confused with larvae of *T. magnus* and *T. volda*, particularly in early instars. Information on separation of larvae of these three species is provided in the remarks section under the descriptions of *T. magnus* and *T. volda*. The shape and colour of the frontoclypeal apotome in fourth instar larvae is much more similar to that of *T. australis*, with which it co-exists. Only relative size of projections on the pronotum allow the two species to be distinguished.

**Habitat and description.** Larvae have been found in large warm lowland permanent rivers which are often sluggish and permanent lakes, often associated with macrophytes.

The known range of the species is Queensland, New South Wales, Victoria and north-west Australia (Neboiss, 1983). The specimens from just inside the South Australian border extend the range slightly.

### *Triplectides ciuskus* Mosely

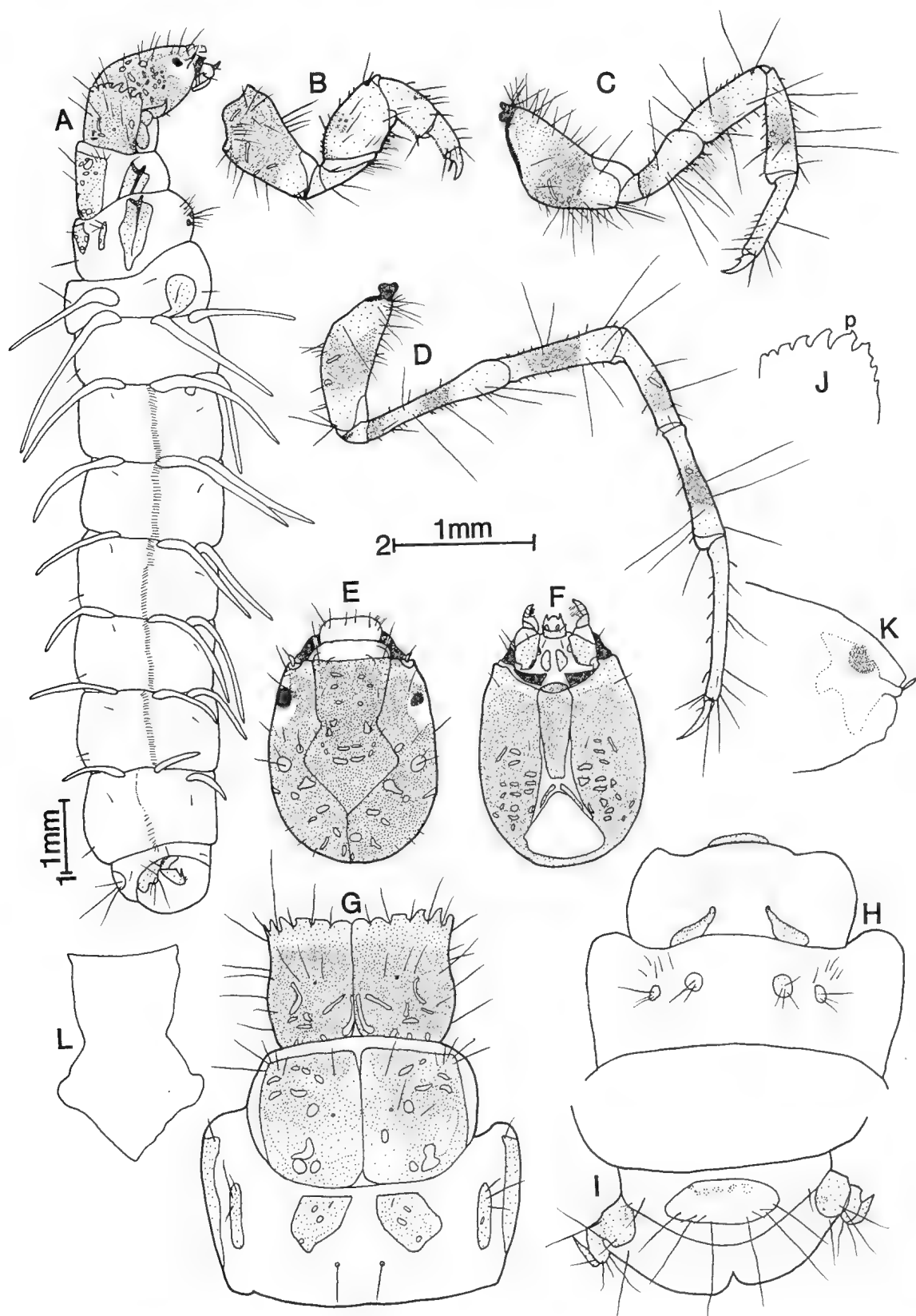
Fig. 16

**Material examined.** Fifty-five reared males, 119 reared females and 283 larvae. VICTORIA: Dairy Creek, 6 km south of Halls Gap, 3 Nov. 1981, 1 male, 1 female; McKenzie River at McKenzie Falls 3 km south-east of Zumsteins, 3 Nov. 1981, 1 male, 1 female; Wannon River, 25 km south-south-west of Halls Gap, 3 Nov. 1981, 2 males, 1 female, 8; Woody Yalaok Creek, 4 km south-west of Cape Clear, 23 Oct. 1984, 7 females, 17; tributary of Hopkins River, 6 km south of Ararat, 3 Jan. 1981, 2 females; Asplin Creek at Gellibrand River, 4 km east of Gellibrand 26 Jan. 1982, 2 females, 6; West Barham River, approximately 8 km north-west of Apollo Bay, 11 Mar. 1984, 28; Grey River, 4 km west-north-west of Kennet River township, 5 Dec. 1983, 18; Erskine River at Erskine Falls near Lorne, 27 Jan. 1982, 1 male, 2 females; Barwon River, 7 km south of Winchelsea, 26 Jan. 1982, 1 male, 6; Mount Emu Creek at Skipton, 28 Apr. 1982, 1 male, 3 females, 9; Coliban River at Trentham falls, Trentham, 11 Nov. 1981, 1 female; Lake Daylesford at Daylesford, 12 Oct. 1983, 1 male, 15; 18 Sept. 1984, 32; Lerderberg River, 4.8 km west-north-west of Blackwood, 27 June 1982, 1 female, 23 Dec. 1982, 1 female, 20 Jan. 1983, 1 male, 18 Sept. 1984, 1 female; Main Creek, 18 km north-west of Flinders, 10 Jan. 1982, 2 males (incl. PT-885), 5 females; Woori Yallock Creek, 6 km west of Yarra Junction, 16 Oct. 1981, 1 female; Yarra River at Millgrove, 27 Nov. 1981, 4 males (incl. PT-887), 2 females; Acheron

River at Taggerty, 30 Jan. 1982, 3 males, 4 females, 29; Acheron River at Acheron, 30 Jan. 1982, 3 males, 6 females; Howqua River, 18 km south-east of Merrijig, 31 Jan. 1982, 1 female; Seven Creeks approximately 1 km south-east of Strathbogie, 1 Feb. 1982, 6 males, 6 females, 16; Tarago River on Labertouche Road, 1 km north of Princes Highway, 6 Nov. 1981, 5 males, 4 females, 18; Traralgon Creek on Traralgon Creek Road, 4.5 km north of Calder Junction, 27 Oct. 1981, 1 male; Stony Creek at Cheshunt, 2 Oct. 1982, 2 males, 3 females, 14; King River at Cheshunt, 2 Oct. 1982, 4 females; Dandongadale River, 3 km west of Dandongadale, 2 Oct. 1982, 2 females, Ovens River at Porepunkah, 2 Oct. 1982, 5 females, 30; Lake Catani, Mount Buffalo, 5 Dec. 1982, 1 male, 4 females; Mitta Mitta River at Glen Valley, 30 Sept. 1982, 1 female; Snowy Creek, 8 km south-east of Mitta Mitta, 30 Sept. 1982, 2 females; Bundarra River, 16 km north-west of Omeo, 1 Oct. 1982, 1 male, 4 females; Cobungra River, 15 km north-west of Omeo, 1 Oct. 1982, 2 males, 4 females; Tambo River, 17 km south-east of Omeo, 30 Sept. 1982, 4 females; Prospect Creek, 5 km north-west of Mount Taylor, 15 Nov. 1983, 1 female; Cobannah Creek, 4 km east-south-east of Cobannah, 15 Nov. 1983, 13; Billabong beside Wongungurra River, approximately 3 km north-north-west of junction with Wonangatta River, 18 Nov. 1984, 1 (PT-908); Simpsons Creek, 11 km south-west of Orbost, 14 Oct. 1982, 14, 30 Nov. 1982, 8 females; Brodribb River, 24 km north-north-east of Orbost, 14 Oct. 1982, 1 female; Rich River, 26 km north-north-east of Orbost, 14 Oct. 1982, 2 females; Bemm River on Princes Highway East Gippsland, 14 Oct. 1982, 2 males, 1 female; Cabbage Tree Creek on Princes Highway East Gippsland, 14 Oct. 1982, 10; Bellbird Creek on Princes Highway East Gippsland, 13 Oct. 1982, 1 female; Back Creek, 1 km north-east of Noorinbee North, 13 Oct. 1982, 2 males, 5 females; Rodger River, 23 km south-west of Bonang, 2 Nov. 1983, 1 male, 1 female; Tonghi Creek on Princes Highway East Gippsland, 4 Jan. 1982, 1 male, 2 females; Wingan River, on Princes Highway East Gippsland, 3 Jan. 1982, 8 males, 4 females; Genoa River, 1 km south-east of Wangarabell, 3 Jan. 1982, 3 males, 8 females. NEW SOUTH WALES: Murray River at Tom Groggin, 19 Nov. 1982, 17; Back Creek, 16 km south-east of Glen Innes, 20 May 1983, 1 male; Little Henry River, 17 km south-east of Glen Innes, 20 May 1983, 2 males, 4 females; Water Cress Creek on Coffs Harbour-Ebor Road, 24 May 1983, 1 male, 4 females. SOUTH AUSTRALIA: Eight Mile Creek at mouth approximately 10 km east of Port MacDonnell 21 May 1984, 1 male, 1 female, 7.

**Diagnosis.** *Triplectides ciuskus* is sometimes indistinguishable from *T. australicus* larvae, as discussed under *T. australicus* group. Most *T. ciuskus* larvae can readily be identified by the presence of the backward projection on the posterior margin of the pale patch around the eye (Fig. 16K) and the dark colour of the head and thorax. The following characteristics also usually hold: presence of strong banding on the legs; small or no spots on the frontoclypeal apotome at the constriction; absence of the spot in the posterior tip of the frontoclypeal apotome in fifth instar larvae; the presence of a large knob on each side of the frontoclypeal apotome at the widest point; the distinct boomerang-shaped spots in the midline of the pronotum posteriorly; spots on head ventrally distinct.

Larvae in the first 4 instars may have a yellow spot in the posterior tip of the frontoclypeal apotome, in a



**Fig. 16.** *Tripleptides ciuskus* larva (PT-908, A.-J.). A – body lateral view, B – right foreleg, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner, K – head lateral view, L – frontoclypeal apotome. A – scale 1, B-J – scale 2, K-L – not to scale. p – projection.



similar position to *T. volda*, causing confusion with larvae of that species.

**Description.** *Head.* Width 0.83-1.13 (n=231, 10 sites); oblong dorsally; usually brown or black but can be orange, with yellow or orange lightly or strongly contrasting spots, frontoclypeal apotome usually without (at most small) yellow patches at constriction, fifth instar larvae never with yellow spot in posterior tip, pale patch around the eye with conspicuous backward projection towards top of anterior margin posteriorly (Fig. 16K), this projection rarely small; frontoclypeal apotome widest behind constriction, usually irregular in shape at widest point, most commonly with rounded knob on each side at widest point (Fig. 16L); but several other shapes occur, often different on different sides of frontoclypeal apotome; ventral apotome tapering but still fairly broad posteriorly, about half anterior width; left mandible with 6 teeth, right mandible with 4 or 5 teeth.

*Thorax.* Pronotum usually brown but can be dark brown or orange, with yellow spots, pair of spots on midline posteriorly usually narrow, distinct, boomerang shaped, rarely broad and diffuse, with projections of anterior margin usually truncate rectangles but these vary in length, width and shape, rarely 2 projections fuse to form one broad one; metanotum with 4 sclerites as shown in Figure 16, medial sclerites pale brown with yellow spots, lateral sclerites pale brown; foretrochantin broad based usually with short upturned section; prosternal sclerite dark brown; mesosternal sclerites very pale with brown margin; 11-34 metasternal setae, most associated with 4 small sclerites, rarely 3 when 2 on one side fuse, setae not associated with these sclerites may have small sclerite at base; legs yellow to orange with brown to dark brown or black pigment bands, bands often with yellow spots, hind tibia divided.

*Abdomen.* Lateral hump sclerite pale brown posteriorly, yellow anteriorly; gills single filaments, arranged as in diagram in table 1; tergite IX very pale, often only seen due to pale brown spots towards anterior of tergite; lateral sclerite and ventral sole plate orange to brown; anal claw moderately large and with 2 or more accessory hooks on outer margin.

*Body length.* 8-15 mm.

*Case.* Commonly hollowed twig or stem, often with detritus added around opening. Sometimes bundled sticks used or untidy case made of pieces of detritus. Very rarely stones or snail shells used in case construction. Case usually not much longer than larva, rarely up to twice length of larva, very rarely longer. Larvae in first 3 instars usually use sand cases of other leptocerids or other caddises, these usually distinguished from those of original owner because *T. ciuskus* larvae add detritus anteriorly. Some early instar larvae make their own untidy cases of detritus.

*Early instar larvae.* Fourth instar larvae generally fit description above but ventral apotome tapers to point ventrally, head width 0.55-0.78 mm (n=158). Third instar larvae much more difficult to identify and have legs banded, typical shape of the pale patch around the

eye, some small projections on pronotum, frontoclypeal apotome widest behind constriction although shape much more similar to that of *T. australis* and ventral apotome shorter than head ventrally, head width 0.31-0.45 (n=190). Second instar larvae legs banded, otherwise no characteristic features, head width 0.21-0.28 mm (n=114).

**Habitat and distribution.** Larvae of this species are common in Victoria in a wide range of habitats. They occur in cool foothill streams but are more common in lower warmer sections of creeks and rivers, and can be found in still or sluggish waters and even intermittent streams. In forested streams they are usually found in log jams and detritus accumulations while in cleared reaches they are often associated with riparian vegetation. This species has previously been recorded from Northern Territory, Queensland, New South Wales, Victoria and Tasmania (Neboiss, 1983). This is the first record from South Australia.

### *T. australis* group

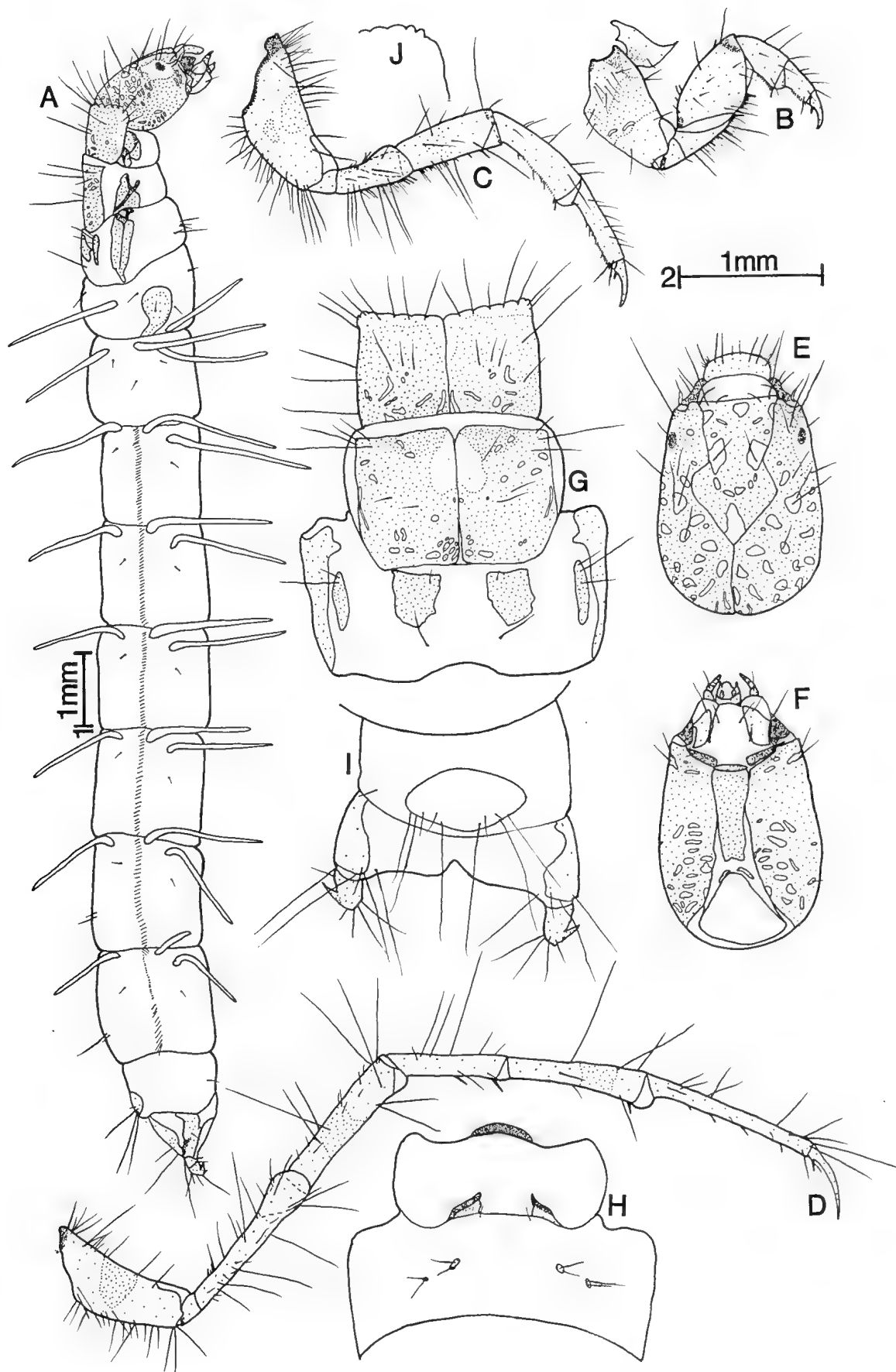
Larvae of *T. australis*, *T. magnus* and *T. volda* are described here, larvae of the other two species in this group are unknown.

**Diagnosis.** Frontoclypeal apotome as wide behind constriction as at anterior margin; pronotum with large projections on anterior margin (in 2 of 3 species); metanotum with 4 sclerites; metasternum with 3-31 setae.

### *Triplectides australis* Navás

Figs 17, 24N

**Material examined.** Twenty-five reared males, 35 reared females and 131 larvae. VICTORIA: swamp near Lake Mundi approximately 35 km west-north-west of Casterton, 28 Apr. 1982, 5 males, 7 females, 14; dam approximately 13 km west of Casterton, 28 Apr. 1982, 2 males, 1 female; dam at Toolondo, 27 Apr. 1982, 1 female; Clear Lake at Toolondo, 28 Apr. 1982, 1 male; Mount William Creek, 16 km south-east of Halls Gap, 2 Dec. 1983, 3 males, 5 females, 18 (incl. PT-937); McKenzie Creek, 6 km south of Horsham, 2 Nov. 1981, 2 females, 2; Bungalong Creek, 4 km south of Horsham, 27 Apr. 1982, 1 female; Hopkins River at Hexham, 4 Dec. 1983, 3; Mount Emu Creek, 10 km north-west of Gnotuk, 4 Dec. 1983, 1; Mount Emu Creek at Trawalla, 2 Dec. 1983, 2; swamp 8 km north-east of Princetown, 4 Dec. 1983, 2 males, 4 females, 4; swamp beside Gellibrand River, approximately 7 km south-east of Princetown, 5 Dec. 1983, 4 males, 3 females, 6; Lake Daylesford at Daylesford, 12 Oct. 1983, 1; Farm dam at Lyonville, 18 Nov. 1981, 1; Jock Marshall Reserve dam, Monash University, Clayton, Sept. 1981, 1 female, 23 Nov. 1983, 2 males (incl. PT-899), 6 females, 11 July 1984, 9, 12 Jan. 1985, 1 female; Balcombe Creek, Bungower Road, Mornington, 11 Jan. 1982, 2 males, 2 females; Balcombe Creek near Balcombe Army Camp, Nepean Highway



**Fig. 17.** *Triplectides australis* larva (PT-937). A – body lateral view, B – right foreleg and foretrochantin, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner. A – scale 1, B-J – scale 2.

Mornington, 14 Oct. 1984, 1; Sheepwash Lagoon approximately 10 km north-east of Yea, 1 Feb. 1982, 4, 2 Oct. 1982, 1 male, 6; a saline tributary of Sunday Creek, Lot 6 Dockery's Road, Tallarook, S. Schreiber, Nov. 1983, 2; Dam, Dookie Agricultural College, A. Sokol, 30 Nov. 1983, 12; billabong approximately 3 km north of Eskdale, 30 Sept. 1982, 2; Billabong (Ryan's II) 5 km east of Wodonga, 29 Sept. 1982, 7 females, 4; Lake Bunga (estuarine) 3 km north-east of Lakes Entrance, 15 Oct. 1982, 2 males, 1 female, 2; Simpson's Creek, 11 km south-west of Orbost, 14 Oct. 1982, 1, 3 Jan. 1983, 1; Wigan River on Princes Hwy, East Gippsland, 3 Jan. 1982, 1. NEW SOUTH WALES: Lake Wyangan near Griffith, 10 May 1982, 4. SOUTH AUSTRALIA: Stubb's Waterhole, Arkaroola Creek, Mount Painter Sanctuary, Flinders Ranges, 10 Sept. 1984, 1 male, 6; Farm dam 2 miles west of Quorn, D. Morton, 14 July 1974, 4. WESTERN AUSTRALIA: roadside ditch, Gidgegannup area, 12 Jan. 1986, A. Boulton, 16.

**Comment.** Morse & Neboiss (1982) note that the literature references to *Triplectides magnus*, often as *Notanotica magna*, may refer to this species. The only larval description (based on specimens from Java and Sumatra) that enables specific identification (Ulmer, 1955) does not fit the present description. Korbout (1963) provided notes on larvae said to belong to this species but the details are insufficient for positive identification.

**Diagnosis.** Within the *T. australis* group, this species is readily recognised by the distinctive shape of frontoclypeal apotome; presence of a yellow patch on either side of the frontoclypeal apotome at the constriction and a third in the posterior tip; only light scalloping on the anterior margin of the pronotum. Gill number is surprisingly constant in this otherwise highly variable species.

**Description.** *Head.* Width 0.76-1.08 mm (n=400, 2 sites); oblong dorsally; brown with contrasting yellow spots, frontoclypeal apotome with at least 3 yellow patches, 1 on each side at constriction and 1 in posterior tip, may have up to 3 additional yellow patches on anterior margin, pale patch around eye may have posterior extension on posterior margin; frontoclypeal apotome as wide behind constriction (rarely wider) as on anterior margin, usually straight sided then tapering behind constriction, very rarely either irregular as in *T. ciuskus* or very rounded as in *T. magnus*, if so, usually different on 2 sides; ventral apotome tapering to be about half anterior width posteriorly; left mandible with 6 teeth; right mandible with 4 teeth.

*Thorax.* Pronotum brown with yellow spots, yellow patch anteriorly on midline that may extend across front, anterior margin only lightly scalloped and with at most small projections at anterolateral corners; mesonotum usually with yellow patch in midline at front, brown with yellow spots; metanotum with 4 sclerites arranged as in Figure 17, medial sclerites pale brown to brown, sometimes with yellow spots, lateral sclerites pale brown to brown; rarely with very small sclerites posteriorly on metanotum; foretrochantin broad basally with thin upturned section at moderately acute angle to base;

prosternal sclerite dark brown, broader than in most species; mesosternal sclerites brown with darker anterior margin; 3-16 metasternal setae, most associated with 2-4 small brown sclerites, setae not associated with main sclerites may have very small basal sclerite; legs usually with at least few pale pigment bands, rarely very strongly contrasting bands, hind tibia divided.

*Abdomen.* Lateral hump sclerite light brown; gills single filaments, as in diagram in table 1, almost all specimens with maximum number shown; tergite IX very pale yellow, often difficult to see; lateral sclerite and ventral sole plate very pale yellow; anal claw large, with one, sometimes 2, rarely no accessory hooks on outer margin.

*Body length.* 4-20 mm.

*Case.* Usually hollowed twig or stem, some larvae make case with either bundled stems (Fig. 24N), or large pieces of detritus apparently arranged without order so that a bulky case results. Ti-tree leaves sometimes used resulting in case very similar to that of *Symphitoneuria* (Fig. 24G) larvae using the same leaves. Whole stick or whole stem cases very rarely used by larvae in instars one to 3. Case usually 2 or more times length of larva. In dam at Monash University, Melbourne, larvae usually had cases that floated on water's surface and larvae were collected amongst floating detritus.

*Early instar larvae.* These have 3 yellow patches on frontoclypeal apotome but early instar larvae of other species in *T. australis* and *T. australicus* groups may have same pattern. Fourth instar, and to lesser extent third instar, larvae can be distinguished using absence of projections on pronotum. Head widths: fourth instar 0.51-0.70 mm (n=383), third instar 0.32-0.44 mm (n=227), second instar 0.21-0.31 mm (n=161) and first instar 0.14-0.15 mm (n=29).

**Remarks.** A small number of larvae examined from South Australia and New South Wales were within the range of variation seen in Victorian specimens. Sixteen larvae from Western Australia differed from Victorian specimens in the following ways: i) the three yellow patches on the frontoclypeal apotome smaller, ii) bands on the legs more conspicuous, and iii) detritus cases neater, but the larvae were otherwise within the range of variation seen in Victorian larvae.

Five larvae of *T. cephalotes*, a very closely related species from New Zealand, varied only slightly from the above description. Minor variations in colour pattern outside that seen in Australia and the presence of a gill on the first abdominal segment dorsally were the only differences seen.

**Habitat and distribution.** Larvae were found in slow flowing rivers and creeks, slightly saline creeks, estuaries, swamps, temporary swamps, farm dams, lakes and billabongs, usually in warm water. This species appears to have a rapid generation time and this together with its viviparity (Morse & Neboiss, 1982) may help it to colonise temporary habitats. The specimens examined were from a restricted area of the distribution: Australia

wide except Tasmania (Neboiss, 1983) and New Caledonia (Neboiss, 1986).

*Triplectides volda* Mosely

Figs 18, 24O

**Material examined.** 6 reared males, 8 reared females and more than 75 larvae. VICTORIA: Bungall Creek, 4 km south of Horsham, 2 Nov. 1981, 1 male, 2 females, 27 Apr. 1982, 2 females, 5; Billabong (Ryans II) about 5 km east of Wodonga, 29 Sept. 1982, 1; Lagoon at Tallandoon, 29 Sept. 1982, 4 males (incl. PT-902), 2 females, 13; billabong about 3 km north of Eskdale, 30 Sept. 1982, 1 female; Barkly River, 9 km north-west of Licola, 18 Nov. 1985, 1; Macalister River, 15 km south-south-east of Licola, 6 Nov. 1984, 1; Macalister River, 3 km north-north-east of Licola, 6 Nov. 1984, 3; Macalister River, 11 km, north-north-east of Licola, 6 Nov. 1984, 2; Wongungurra River about 2 km north of junction with Wonangatta River, 7 Nov. 1984, 16 (incl. PT-934); Wonangatta River at Waterford, 6 Nov. 1984, 1 female, 8; Dargo River, 6 km north of Dargo, 8 Nov. 1984, 1 male, 1; Deddick River at Tingaringy track, L. MacMillan, 7 Jan. 1983, 12; Mitta Mitta River, 4 km north of Eskdale Loc. AP. Dartmouth Quantitative Survey, 4 Feb. 1974, larvae. NEW SOUTH WALES: Wamban Creek about 2 km up from Kia Ora bridge on Moruya River, P.S. Lake, 9 Dec. 1985, 12.

**Diagnosis.** Within the *T. australis* group, this species is recognised by: large projections on the anterior margin of the pronotum; yellow spot or stripe in the posterior tip of the frontoclypeal apotome; pale patch around eye usually with a straight posterior margin.

**Description.** *Head.* Width 0.64-0.84 mm (n=43, 10 sites); oblong dorsally; brown to dark brown with contrasting yellow spots; conspicuous yellow patch in posterior tip of frontoclypeal apotome, patches on either side of constriction of frontoclypeal apotome, if present, not conspicuous, pale patch around eye straight posteriorly, rarely with small posterior projection; frontoclypeal apotome as wide behind constriction as on anterior margin, rounded and tapering behind constriction; ventral apotome tapering slightly posteriorly; left mandible with 6 teeth; right mandible with 5 teeth.

*Thorax.* Pronotum brown with yellow anteriorly and yellow spots, anterior margin with large projections, largest on anterolateral corner, rarely with 2 projections fused together to form 1 broad one, projections vary in size and shape; mesonotum pale brown with lightly contrasting pale yellow spots and pale yellow area on midline anteriorly 4 sclerites arranged as in Figure 18; metanotal medial sclerites pale brown with pale yellow spots, lateral sclerites pale brown, sometimes with pale spot; foretrochantin stout basally with upturned section at relatively shallow angle to base; prosternal sclerite dark brown; mesosternal sclerites very pale brown with brown anterior margin; 11-31 metasternal setae, most associated with 4 small pale sclerites, those not associated with sclerites may have very small basal sclerite; legs

yellow with strongly contrasting brown bands.

*Abdomen.* Lateral hump sclerite light brown, paler anteriorly and posteriorly; gills single filaments, as in diagram in table 1; tergite IX very pale, may be difficult to see; lateral sclerite and ventral sole plate pale brown; anal claw moderately large, with 1 rarely 2, accessory hooks on outer margin.

*Body length.* 5-8 mm.

*Case.* Either rough detritus case, sometimes with sand added, or hollowed twig. Some larvae use either sand or secretion cases of other trichopteran larvae but usually add detritus to anterior end (Fig. 24O). Case usually about twice length of larvae although less if hollowed stick used.

**Remarks.** Some details of larval morphology and biological notes are given by Korboot (1963, 1964b). The description in the 1964 paper fits some of the description below but details are not available for head colour pattern.

Because of the small size of many of the fifth instar larvae of this species, confusion is likely with earlier instars of other species, particularly *T. ciuskus* and *T. australicus* both of which may have a spot in the posterior tip of the frontoclypeal apotome in early instars. This can be avoided by careful comparison with size of pronotal projections which are not as long in early instars and comparison with the ventral apotome. The ventral apotome tapers to a point in fourth instar *T. ciuskus* and *T. australicus* larvae and is not as long as the head ventrally in their third instars. *Triplectides ciuskus* can also be identified using the back projection of the margin of the pale patch around the eye although this may be small at times on *T. ciuskus* larvae and present occasionally on *T. volda* larvae. Early instar *T. volda* larvae could not be distinguished from other *Triplectides* larvae with certainty.

**Habitat and distribution.** Larvae were found, usually in warm water, in billabongs and sluggish to fast flowing creeks and rivers. The published distribution of this species is Queensland, New South Wales, Victoria, widespread, coastal. Larvae were collected from some sites that were well inland.

*Triplectides magnus* (Walker)

Fig.19

**Material examined.** Fourteen reared males, 7 reared females and more than 14 larvae. VICTORIA: Lake Gilliear, Warrnambool, Neboiss, 20 Jan. 1953, larvae; Floating Islands Lagoon approximately 15 km west of Colac, 24 Oct. 1984, 1 male, 2 females, 4 (incl. PT-940); Balcombe Creek beside Balcombe Army Camp, Nepean Hwy Mornington, 14 Oct. 1984, 3 males, 2 females, 1; Sheepwash Lagoon approximately 10 km north-east of Yea, 1 Feb. 1982, 2 males (incl. PT-919), 1 female, 1, 2 Oct. 1982, 1 male; Giffard A. Neboiss, 24 June 1953, larvae; Ewings Morass 15 km south-east of Nowa Nowa, 15 Oct. 1982, 1 male, 1; Simpsons Creek, 11 km south-west

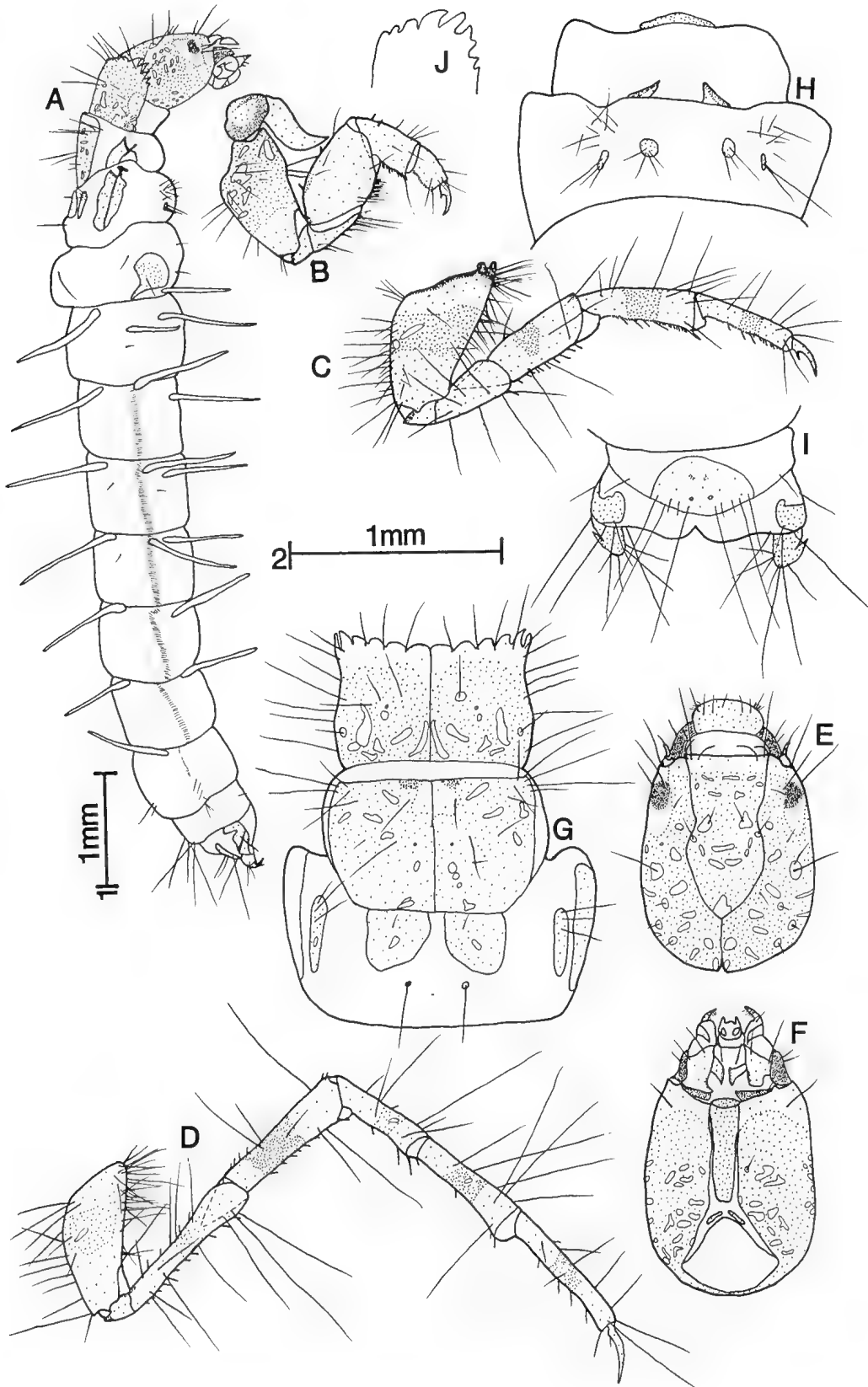


Fig. 18. *Triplectides voldi* larva (PT-934). A - body lateral view, B - right foreleg and foretrochantin, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - thorax ventral view, I - segment IX dorsal view, J - right anterolateral pronotum corner. A - scale 1, B-J - scale 2.

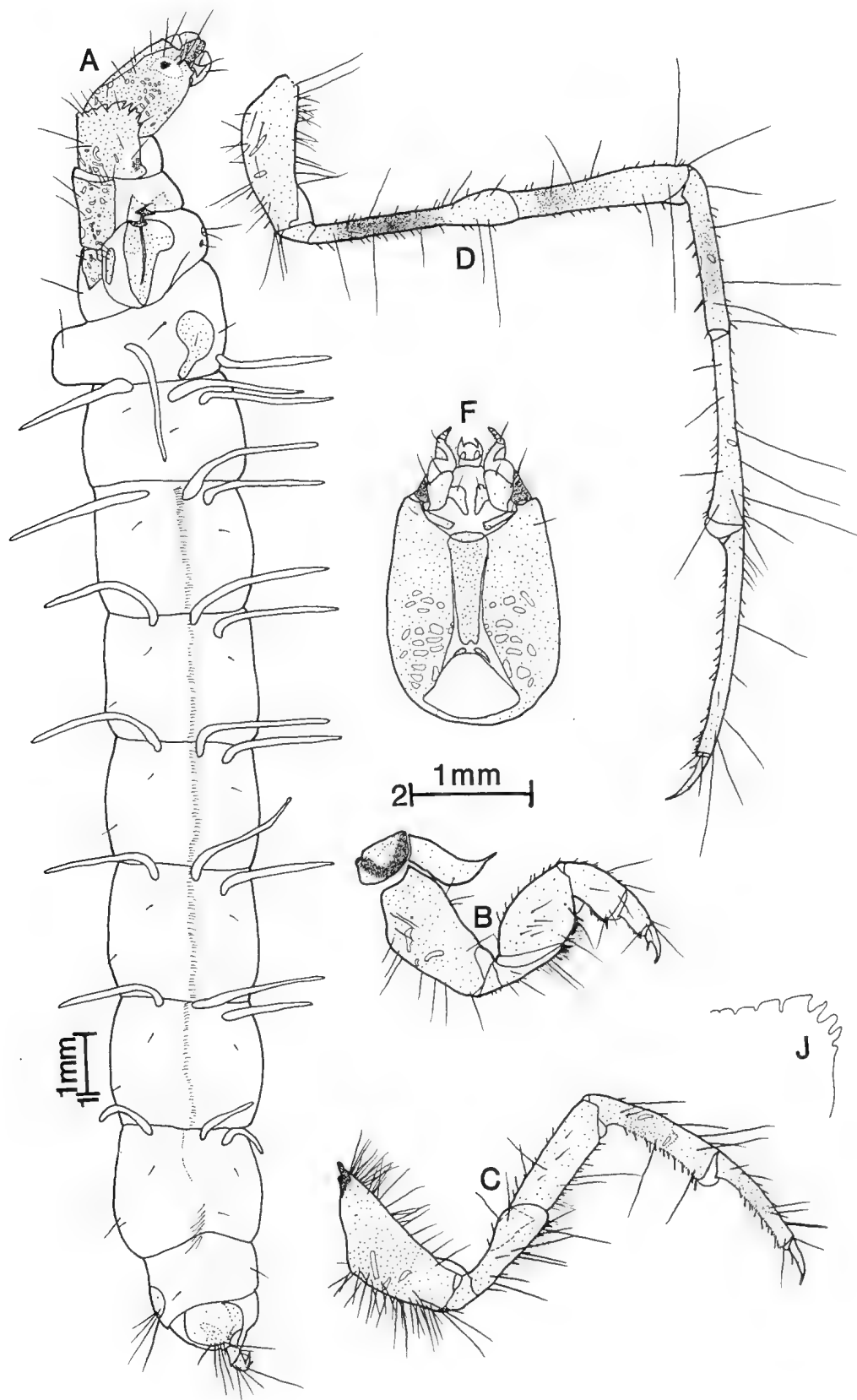


Fig. 19. *Triplectides magnus* larva (PT-940). A – body lateral view, B – right foreleg and foretrochantin, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal view, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner. A – scale 1, B-J – scale 2.

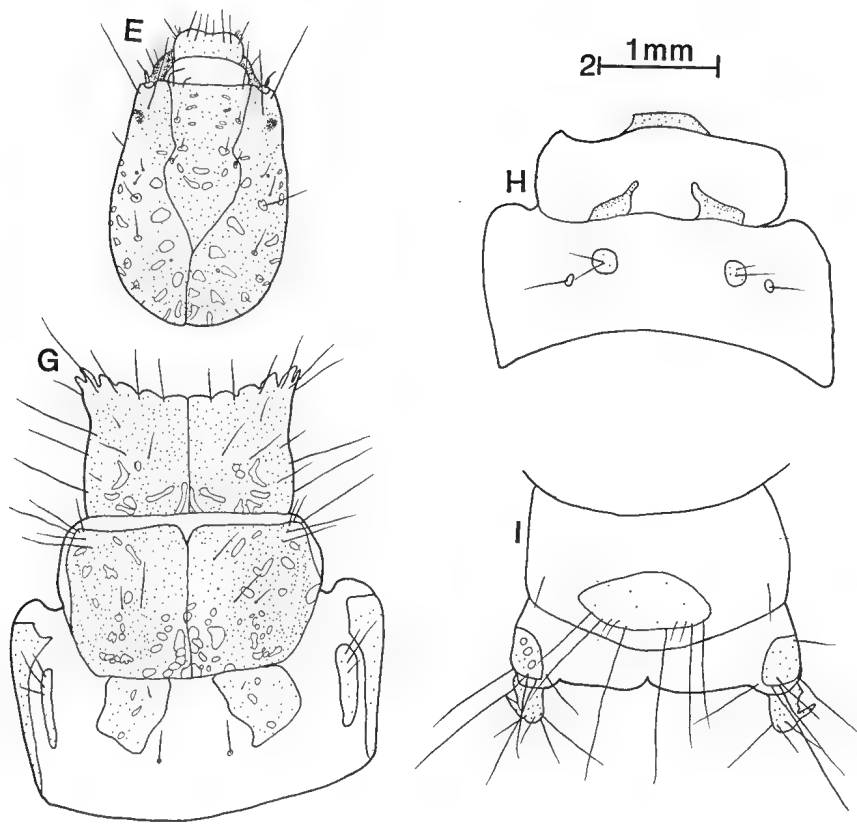


Fig. 19 cont'd.

of Orbest, 14 Oct. 1982, 6 males, 1 female, 7, 3 Jan. 1983, 12; Genoa River at Genoa, 13 Oct. 1982, 1 female; Lake Barracoota, A. Neboiss, 28 Jan. 1975, larvae.

**Diagnosis.** Within the *T. australis* group, this species can be recognised from the following: head orange, elongate, with only small spots in the frontoclypeal apotome. This species is most similar to *T. australicus* and is differentiated from it by head shape and frontoclypeal apotome colour and shape.

**Description.** *Head.* Width 0.95-1.20 mm. (n=13, 5 sites); oblong but comparatively elongate dorsally; orange, rarely brown, with contrasting yellow spots, all yellow spots on frontoclypeal apotome small, some specimens with pale areas at back of head, pale area around eye with posterior margin straight; frontoclypeal apotome as wide behind constriction as on anterior margin, rounded and tapering behind constriction, rarely straight sided as in *T. australis*; ventral apotome tapering till about half anterior width posteriorly; left mandible with 6 teeth, right mandible with 4 teeth.

*Thorax.* Pronotum orange or brown with contrasting yellow spots, anterior margin with large projections particularly at anterolateral corner; mesonotum mottled orange-brown with lightly contrasting yellow spots; metanotum with 4 sclerites arranged as in Figure 19, pale brown with yellow spots, median sclerites paler;

foretrochantin with moderately long to long, thin, upturned section at shallow angle to base; prosternal sclerite brown, mesosternal sclerites pale brown with brown anterior margin; 6-13 metasternal setae, usually associated with 4 small, pale sclerites; legs orange, usually with pigment bands, may be strongly banded, hind tibia divided.

*Abdomen.* Lateral hump sclerite light brown, paler anteriorly; gills single filaments, as in diagram in table 1; tergite IX very pale, difficult to see; lateral sclerite and ventral sole plate pale orange or orange, some with pale spots; anal claw large, with 2 or 3 accessory hooks on outer margin.

*Body length.* 11-17 mm.

*Case.* Hollowed stem or stick. Rarely detritus added around anterior opening. Case usually much longer than larva, up to 3 or more times larval length.

*Early instar larvae.* Fourth instar larvae (head width 0.63-0.73, n=12) are recognisable from the above description. Third instar larvae (0.41-0.44 mm, n=2) and earlier instar larvae may be difficult to distinguish from *T. australicus* larvae of the same instar.

**Remarks.** Larvae said to belong to this species have been described several times, mostly as *Notanotolica magna*. Most of these descriptions are inadequate for specific identification (Tillyard, 1925; Ulmer, 1908). The information provided by Ulmer in 1955 differs notably from all larvae described here and clearly the specimen



he describes belongs to a different species. Morse & Neboiss (1982) say the adult descriptions refer to another species, possibly *T. australis*. The larval description by Ulmer (1955) does not fit the larval description of *T. australis*.

**Habitat and distribution.** Larvae are found, usually associated with rushes or submerged macrophytes, in warm sluggish streams, billabongs and lakes. This species has been recorded in Victoria and Tasmania (Neboiss, 1983). Larvae were collected so far east that they probably extend at least into south-eastern New South Wales.

### *Westriplectes* Neboiss

**Diagnosis.** The generic diagnosis is as for *Symphitoneuria* but with the exception that long setae posterior to the medial metanotal sclerites are absent.

**Description.** Antennae long, greater than half width of frontoclypeal apotome at anterior margin; labrum without secondary setae; mandibles short and wide, teeth grouped around central concavity, similar to Figure 3B, but more squat; left mandible with 2 short setal brushes in central concavity; ventral apotome tapering but still broad posteriorly, comparatively short and broad; without secondary lines of weakness on head; pronotum scalloped anteriorly, anterolateral corners with 3-pronged (rarely 2 or 4-pronged) extension; foretrochantin sinuous, long tapering; metanotum with 4 small anterior sclerites and 4 very short setae posteriorly, often very difficult to see; metasternum with 8-13 setae, all associated with 2 comparatively large, pale brown sclerites; hind tibia divided; gills single filaments; lateral line starts anteriorly on segment III; tergite IX with 4 long and 6 short (most specimens) or 4 long and 4 short setae; anal prolegs without secondary setae.

N.B. This diagnosis and description are based on larvae of one species (*Westriplectes pedderensis*) and from one site only.

**Remarks.** No information is available on the larvae of the other two species in this genus, one from Western Australia (*W. albanus*) and one from north Queensland (*W. angelae*). *Westriplectes pedderensis* and *W. angelae* were recently recorded from Wilsons Promontory, Victoria, A. Neboiss (personal communication).

### *Westriplectes pedderensis* Neboiss

Figs 20, 24P

**Material examined.** VICTORIA: Wilsons Promontory, swamp on Five Mile Track, 1 km east of Tidal River Road,

6 Nov. 1986, 14 males (incl. PT-970), 6 females, 58 (incl. PT-961).

**Description.** *Head.* Width 0.63-0.86 mm (n=15); oblong dorsally; brown or dark brown, rarely mottled, with contrasting yellow spots, a yellow patch on each side of frontoclypeal apotome at constriction, laterally band of yellow spots, antennae brown or dark brown; frontoclypeal apotome widest on anterior margin, with constriction at about half its length, straight sided then strongly tapering, rarely rounded or irregular behind constriction; mandibles comparatively squat, left mandible with 6 teeth, right mandible with 5 teeth.

*Thorax.* Pronotum brown with contrasting yellow spots, mesonotum brown with yellow spots; metanotal sclerites arranged as in Figure 20, medial sclerites brown with yellow spots, lateral sclerites pale brown; foretrochantin with moderately long upturned section; prosternum usually with dark brown sclerite, pale in some specimens; mesosternal sclerites very pale brown or brown; metasternal sclerites rarely subdivide so 3 present on segment; foreleg yellow with some brown mottling on coxa; mid- and hindlegs yellow with light brown or brown banding, bands often most of length of segment.

*Abdomen.* Somewhat dorsoventrally flattened; lateral hump sclerites yellow-brown; short anterior pair of setae on segment I often each with a small sclerite at base, variable in size and colour; lateral line dark; gills as in diagram in table 1; spicules obvious, in a single line, additional spicules to one side of the line, as shown in Figure 20A, only present on specimen figured; tergite IX not apparent; lateral sclerites very pale orange, ventral sole plate orange; setae of anal claw comparatively short; anal claw short and with 1 short accessory hook on outer margin.

*Body length.* 11-14 mm.

*Case.* Made of 2 or more pieces of rush stem, usually one dorsally and one ventrally but may be more. Pieces chosen by the larvae are curved outwards so case, while similar to that of *L. varians*, is more rounded in cross section (Fig. 24P). Additional small pieces of detritus may be added anteriorly or posteriorly. Some cases have additional longer sections that cause case to be quite deep in cross-section. Dorsal surface is longer than ventral so that small hood is formed. Some cases cause larvae to float on surface amongst floating detritus.

*Early instar larvae.* Fourth instar larvae, head width 0.48-0.56 mm (n=14), are similar to above description but have ventral apotome narrower posteriorly, 2 long and 8 short setae on tergite IX, fewer gills and fewer metasternal setae.

**Habitat and distribution.** This species has only been collected from Lake Pedder in Tasmania and one swamp in Victoria. The water in this swamp was humic and there was extensive emergent and submerged macrophytic growth.

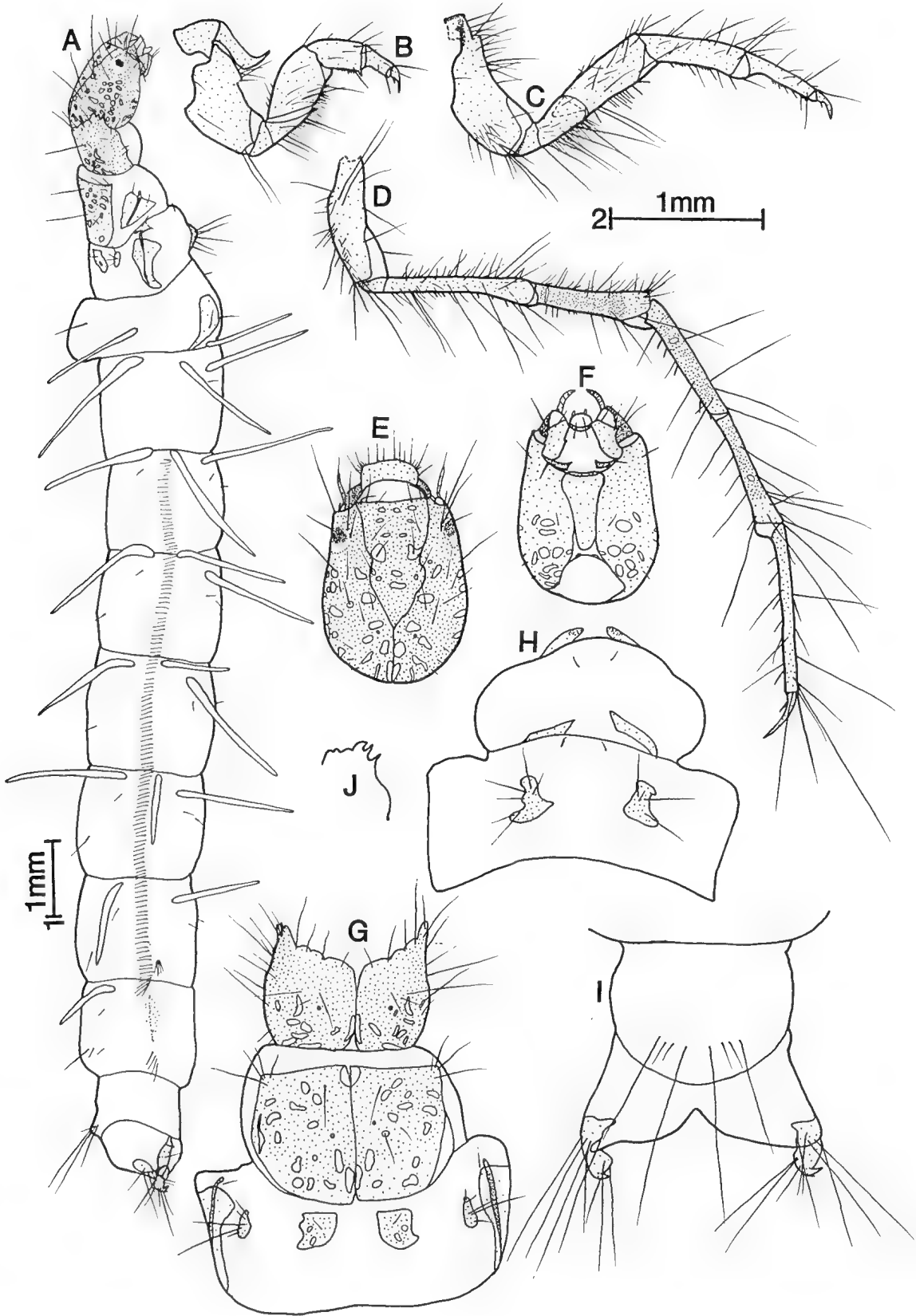


Fig. 20. *Westriplectes pedderensis* larva (PT-961). A – body lateral view, B – right foreleg and foretrochantin, C – right midleg, D – right hindleg, E – head dorsal view, F – head ventral view, G – thorax dorsal, H – thorax ventral view, I – segment IX dorsal view, J – right anterolateral pronotum corner. A – scale 1, B-J – scale 2.

## Leptocerinae

### *Leptorussa* Mosely

**Diagnosis.** The combination of 2 small sclerites on the metanotum, ventral apotome short and broad, gills divided into filaments and anal proleg without secondary setae defines this genus.

**Description.** Antennae long, approximately one third width of frontoclypeal apotome at anterior margin; labrum without secondary setae; mandibles short and wide, teeth grouped around central concavity, similar to Figure 3B but little more slender; left mandible with 2 short setal brushes in central concavity; ventral apotome comparatively short and broad, almost square; without secondary lines of weakness on head; pronotum with anterior margin straight, anterolateral corners smoothly rounded; foretrochantin sinuous, long tapering; metanotum with 2 small irregularly rounded sclerites; metasternum with 4-10 setae without associated sclerites; hind tibia undivided; gills divided into several filaments; lateral line starts anteriorly on segment III; ninth tergite with 2 long and 4 short setae; anal prolegs without secondary setae.

**Remarks.** This genus is monotypic. The larvae of this genus do not fit the subfamily description, as the head does not have additional lines of weakness, prosternal sclerites are present, the foretrochantin is sinuous, long tapering and small sclerites are present medially on the metanotum.

### *Leptorussa darlingtoni* (Banks)

**Material examined.** 31 reared males, 20 reared females and 294 larvae. VICTORIA: swamp near road at Bullarto, 12 Oct. 1983, 7 males, 1 female, 30; Lerderg River, 4.8 km west-north-west of Blackwood, 23 Dec. 1982, 1 female, 16 Aug. 1983, 31; Kangaroo Creek, 2 km south-west of Glenlyon, 12 Oct. 1983, 4; Churchill National Park, abandoned aqueduct in north-east corner, 7 Oct. 1984, 17; pond beside Acheron River, 3 km north-north-east of Narbethong, 16 Oct. 1981, 1 male, 50; temporary pond 4.5 km south-east of Tanjil Bren, A. Sokol, June 1981, 2 males, 4 females, 25; temporary pond 2.7 km south of Tanjil Bren, A. Sokol, June 1981, 2 males; Warrigul Creek, 9 km south of Giffard, 16 Nov. 1983, 17 (all in second instar); Prospect Creek, 5 km north-west of Mount Taylor, 15 Nov. 1983, 1; Swamp approximately 4 km south-south-west of Kingswills Bridge on Wonnangatta River, 15 Nov. 1983, 3 males, 6 females, 11; Cobannah Creek, 4 km east-south-east of Cobannah, 15 Nov. 1983, 10 males, 4 females, 61; Billabong beside Wungungurra River, approximately 3 km north-north-west of junction with Wonnangatta River, 8 Nov. 1984, 6 males, 4 females, 46; Betka River, 6 km west-south-west of Mallacoota, 5 July 1983, 1.

**Comments.** The larvae of this species have been described and figured from South Australia by Jackson (1985). The following is additional notes to her description

and details of variation found in Victorian specimens. Photographs of the larva and an ovipositing female are provided by Towns (1983) and notes on the biology of the larvae are given by Towns (1985) and Jackson (1984).

**Description.** *Head.* Width 0.45-0.59 mm (n=1,019 larvae from one site); colour pattern variable, usually brown with yellow patches and darker brown spots but some individuals pale orange with darker spots and poorly contrasting pale yellow patches; frontoclypeal apotome usually with pale cross anteriorly often with 4 brown spots in the cross, pale patch on each side at constriction and stripe from posterior tip, some or all pale patches may join; pale stripe usually at back of head dorsally on each side, sometimes broad with brown spots and sometimes joined to pale area around eye; usually dark spots behind pale area around eye laterally.

*Thorax.* Pronotum and mesonotum variable in colour, usually brown, some specimens with darker spots and some with yellow patches of highly variable size. Foretrochantin with tip comparatively short so less sinuous than in most larvae with sinuous foretrochantin.

*Abdomen.* Green or yellow when alive; gills arranged as in diagram in table 1; lateral hump sclerites very pale yellow; lateral line setae very pale and short; tergite IX very pale yellow, usually difficult to see, with highly variable brown areas, these areas usually divided so that there appears to be 2 small brown sclerites; lateral sclerite and ventral sole plate very pale yellow with brown patches less variable than on tergite IX.

*Case.* Distinctive sand grain case that may have numerous small rounded projections added to sides and top. Often sudden change in colour of sand used suggests different coloured sand used to that from previous building episodes. Hatchlings make less regular sand tube.

*Early instar larvae.* Case type and presence of the small metanotal sclerites aid in identification of even very small larvae. Head widths: fourth instar 0.31-0.42 mm (n=607); third instar 0.22-0.28 mm (n=828); second instar 0.15-0.21 mm (n=908); first instar 0.11-0.14 mm (n=257), all from one site.

**Habitat and distribution.** Larvae are found in temporary swamps, flood filled pools beside rivers, temporary ponds and pools in temporary streams. They occur in subalpine to lowland water bodies. The recorded distribution is New South Wales, Victoria, Tasmania and South Australia (Neboiss, 1983).

### *Russobex* St Clair

**Comments.** The larvae of the only known species in this genus was described in St Clair (1988). I placed the genus in the Leptocerinae between *Leptorussa* and *Athripsodini* in the phylogenetic scheme of Morse (1981). This is confirmed from larval characters. The larvae of *Russobex* share with the larvae of *Leptorussa* i) the lack

of additional lines of weakness on the head and ii) a sinuous, long tapering foretrochantin. *Russobex* differs in that it has lost the metanotal sclerites and in this respect is more closely related to the rest of the Leptocerinae than is *Leptorussa*.

### *Leptocerus* Leach

**Diagnosis.** The hook on the modified claw of the midleg is distinctive of this genus.

**Description** (based on Australian species). Antennae long, almost as long as anterior margin of frontoclypeal apotome; labrum without secondary setae; mandibles short and wide, with semicircular ridge or ridge with few small teeth around a central concavity (worn?); left mandible with 2 short setal brushes in central concavity; ventral apotome not obvious, not completely dividing genae; head with additional lines of weakness; pronotum with anterior margin straight, anterolateral corner rounded; foretrochantin short and obtuse; metanotum without sclerites; metasternum with 2 setae, without sclerites; claws of midleg modified to form hook; hind tibia undivided; gills single filaments; lateral line absent; tergum IX with 2 long and 4 short setae; anal prolegs without secondary setae.

**Remarks.** This description is based on only one of the four Australian species. This genus is worldwide in distribution and several larval descriptions are available. The main characters in the generic description are comparable with overseas species of *Leptocerus* (Lepneva, 1966; Wallace, 1981; Wiggins, 1977). Metasternal setae and mesosternal sclerites were not figured or discussed in most of the overseas descriptions and so cannot be compared.

### *Leptocerus souta* Mosely

Figs 21, 24Q

**Material examined.** VICTORIA: Campaspe River, 5 km north-west of Woodend, 19 Nov. 1981, 1 male, 2 females, 4 (incl. PT-914); Lake Purrumbete at Camperdown, A. Neboiss, 27 July 1953 and 28 Aug. 1953, numerous larvae. Recent attempts to collect more specimens from both localities were unsuccessful.

**Description.** *Head.* Width 0.44 mm (n=1); oblong dorsally; yellow with brown spots, white at back, ventrally yellow laterally, medially mostly white with brown and dark brown patches, rarely patches much paler; frontoclypeal apotome long, thin and fairly straight sided, almost reaching back of head.

*Thorax.* Pronotum yellow with pale brown patches and brown spots; mesonotum mottled yellow and pale brown with brown spots; foretrochantin truncate; mesosternum

with brown lateral sclerites; legs yellow with few pale brown spots; 2 setal fringes on femur, tibia and tarsus of hind leg at about 180° from each other.

*Abdomen.* Green when alive, colour shows through case; lateral hump sclerites very pale; dorsal hump with thin transverse line of sclerotisation medially; 3 pairs of gills on second segment as shown in Figure 21, some with only 2 pairs of gills, some with 2 or 3 pairs of gills on segments II and III; tergite IX very pale yellow; lateral sclerites and ventral sole plate brown; anal claw with 2 accessory hooks on outer margin, one smaller than other; numerous moderately long setae between prolegs ventrally.

*Body length.* About 4 mm.

*Case.* Made entirely of silk or has few scattered sand grains incorporated in silk, but remains translucent (Fig. 24Q), about twice as long as larva.

**Habitat.** This species is only known from a large freshwater lake and a deep pool in a very sluggish river, both with extensive macrophyte growths. This species has previously only been recorded from South Australia and Queensland (Neboiss, 1983).

### *Triaenodes* McLachlan

**Diagnosis.** The case type is the most characteristic feature of larvae belonging to this genus, others include; ventral apotome rectangular, hind tibia divided, numerous short setae in 2 bands between prolegs ventrally.

**Description** (based on Australian species). Antennae long, almost as long as width of frontoclypeal apotome on anterior margin; labrum without secondary setae; mandibles short and wide, teeth grouped around central concavity similar to Figure 3B; left mandible with 2 short setal brushes in central concavity; ventral apotome rectangular, comparatively short; head with additional lines of weakness; pronotum anterior margin straight, anterolateral corner rounded; foretrochantin short and obtuse; metanotum without sclerites; metasternum with 6-16 setae, without sclerites; hind tibia divided; gills absent; lateral line absent; tergite IX with 2 long and 4 short setae or 6 long and 4 setae; anal prolegs without secondary setae; numerous short setae in 2 bands between prolegs ventrally.

**Remarks.** This genus is worldwide in distribution and descriptions of larvae of several species are available (eg, Wallace, 1981; Wiggins, 1977; Lepneva, 1966). In Australia adults of only four species are described but many new species are awaiting description (Neboiss, personal communication).

Comparatively few larvae of this genus were reared during this study. Of those reared, adults of only one species could be identified, which is described here. Larvae of four or more species reared but not yet described, also fitted the generic description above.

However, larvae of one species had the division of the hind tibia very pale and indistinct so that care is necessary when using the key to genus for at least one species of *Triaenodes*.

The larvae of *T. bernaysae* Korboot was described by Korboot (1964c) but insufficient information was given for specific identification; the adult of *T. bernaysae* is redescribed and difficulties with the type material discussed by Neboiss (1987).

Information is also available for larvae from other countries (Lepneva, 1966; Wallace, 1981; Wiggins, 1977). These larvae also fit the generic description above apart from number of metasternal setae and presence of gills. The Australian species appear to be the only ones

without gills. In North America presence or absence of gills on certain segments are the only larval characters used to separate *Ylodes* and *Triaenodes* (Manuel & Nimmo, 1984).

As well as the additional lines of weakness found on the heads of most larval Leptocerinae, larvae of *Triaenodes* have a line branching from behind the eye and extending to near the back of the head so that a small lateral apotome is formed (Fig. 22). This is difficult to see in pale specimens but was present in all Australian species examined. This is not mentioned for any of the species from the northern hemisphere but is figured by Lepneva (1966: fig.782). This lateral apotome rarely divides from the parietals completely at ecdysis.

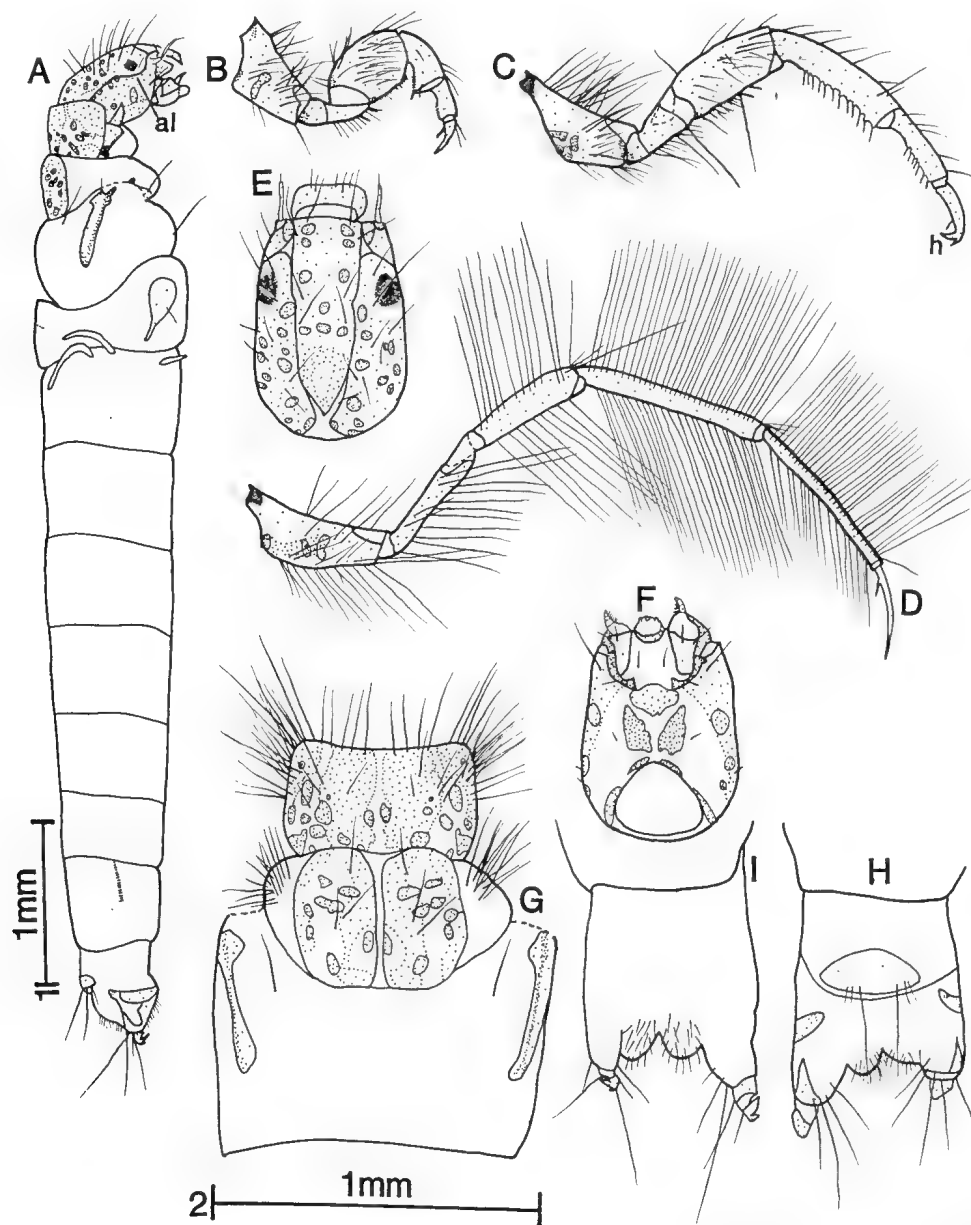


Fig. 21. *Leptocerus sounta* larva (PT-914). A - body lateral view, B - right foreleg, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - thorax ventral view, I - segment IX dorsal view. A - scale 1, B-I - scale 2. al - additional line of weakness, h - hook-like claw on midleg.

Larvae of this genus have a case made of spirally arranged short, thin, regular plant sections. In Australia, some species of *Notalina* make a similar case.

### *Triaenodes voldi* Mosely

Figs 22, 24R

**Material examined.** Thirteen reared males, 11 reared females and 30 larvae. VICTORIA: Ovens River at Porepunkah, 2 Oct. 1982, 7 males (incl. PT-932), 6 females, 13 (incl. PT-928); King River at Cheshunt, 2 Oct. 1982, 5 males, 3 females, 16; Macalister River, 15 km south-south-east of Licola, 6 Nov. 1984, 1 male, 2 females; north arm of Lake Glenmaggie, 6 Nov. 1984, 1.

**Description.** *Head.* Width 0.44-0.52 mm (n=15, 2 sites); oblong dorsally; short ventrally; dark brown with variable pale patch at back of frontoclypeal apotome and variable pale stripe on each side from back of head joining with pale area around eye dorsally; some dark spots laterally; frontoclypeal apotome long, thin with fairly straight sides and brought to point posteriorly; left mandible with 6 teeth and right mandible with 5 teeth.

*Thorax.* Pronotum mottled brown; mesonotum pale yellow with brown spots, spots variable in number and position; metanotum with 2 pairs of setae; foretrochantin truncate, slightly longer dorsally than ventrally; prosternum with 2 pairs of short setae anteriorly; mesosternum with pair of short setae anteriorly and dark brown lateral sclerite on posterior margin; metasternum with pair of short setae anteriorly and transverse row of 8, rarely 6 or 7, setae towards posterior margin; legs pale brown, 2 long setal fringes at approximately 180° from each other on hind femur, tibia and tarsus.

*Abdomen.* Lateral hump sclerite very pale yellow with pale brown stem; spicules pale; tergite IX roughly square, very pale brown (sometimes difficult to see); lateral sclerite and ventral sole plate very pale brown; claws with 2 or 3 very small accessory hooks on outer margin.

*Body length.* 3-7 mm.

*Case.* Made of short thin sections of fairly fresh brown plant matter spirally arranged (Fig. 24R). Varies from about length of larva to about twice as long as larva but is most commonly about one and one-half times as long.

*Early instar larvae.* Fourth instar larvae (head width 0.30-0.33 mm, n=3) have no spots on the head or thorax, no additional lines of weakness on head, 8 metasternal setae and ventral apotome triangular but completely dividing genae.

**Habitat and distribution.** Larvae were collected amongst vegetation in large rivers with submerged sedge, fine willow roots or macrophyte beds. This species has previously only been recorded from south-east Queensland (Neboiss, 1983).

### *Oecetis* McLachlan

**Diagnosis.** The long maxillary palpi and single-blade mandibles distinguish all known species in this genus.

**Description** (based on Australian species only). Antennae moderately long to very long, about one-quarter to over half width of frontoclypeal apotome on anterior margin; labrum with secondary setae; mandibles long and thin, blade-like, with few teeth on cutting edge and without setae (Fig. 3C); ventral apotome triangular, short, not completely dividing genae; head with additional lines of weakness; pronotum with anterior margin straight, anterolateral corners rounded; foretrochantin short and broad; metanotum without sclerites; metasternum with 2 to numerous setae without sclerites at base; hind tibia undivided; gills single filaments; lateral line short and pale; tergite IX with 6 long and 4 short setae in some species, numerous setae in others; anal prolegs without secondary setae.

**Remarks.** *Oecetis* is another worldwide genus and larval descriptions from other countries are available (Wallace, 1981; Wiggins, 1977; Lepneva, 1966). In Australia 19 species have been described but the genus is in need of revision and several new species await description (Neboiss, personal communication).

Larvae belonging to this genus were commonly collected during this study but only a small proportion survived and emerged. This is probably due to lack of suitable food as larvae of *Oecetis* are generally predatory (Wiggins, 1984). Identification of many of the reared animals is tentative as they belong to undescribed species or are variants of described species. For this reason larvae of only one species, *O. laustra* Mosely, are described here. Larvae of the other eight or more species were variable in the following features.

*Head.* Colour pattern; frontoclypeal apotome straight sided and narrow, narrow with small lateral extensions or fairly broad; some species with secondary setae.

*Thorax.* Segments long and thin or short and broad; some species with secondary setae all over thorax; colour pattern; setae present or absent on mesosternum; setae few or numerous on metasternum; legs with variable number of setae, larvae with sand cases generally have fewer setae; length of tarsal claws; length of basal seta on tarsal claw; shape of foretrochantin.

*Abdomen.* Most species with gills as shown for *O. laustra* but may also have gills on first abdominal segment, some with very few gills; lateral sclerites striped or comparatively uniform colour; anal claws with 1-3 teeth on outer margin.

*Case.* The case is: i) square in cross section and made of green macrophyte sections, as shown for *O. laustra* (Fig. 24S), larvae swim with these cases; ii) a similar case made of detritus instead of green macrophytes; iii) a curved detritus case; iv) various sand grain cases.

The larva of *Oecetis australis* (Banks) described by Korboot (1964a) as *O. situlus* Korboot is clearly the larva of *Notalina spira* St Clair (see St Clair, 1991).



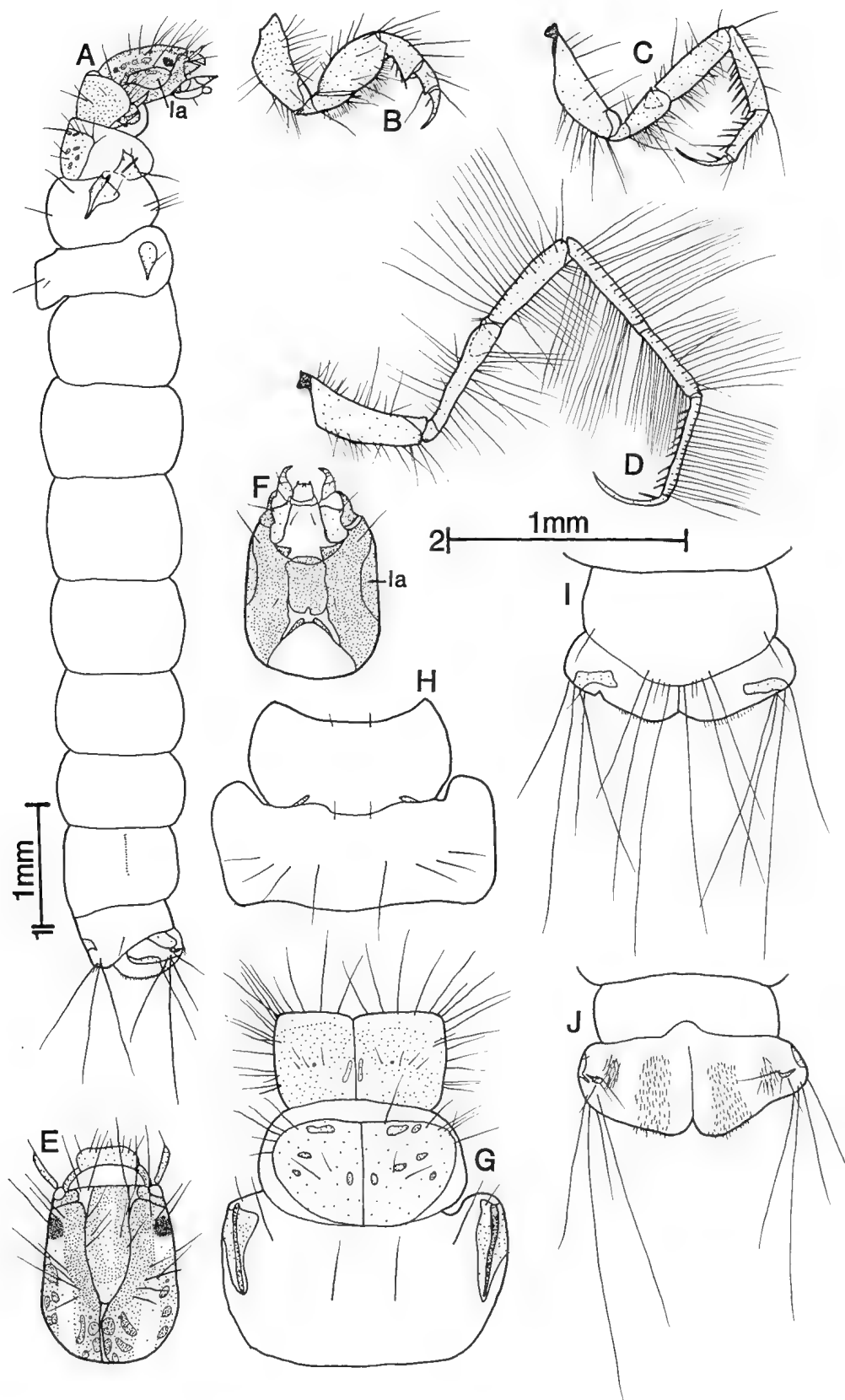


Fig. 22. *Triaenodes voldi* larva (PT-928). A - body lateral view, B - right foreleg, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - thorax ventral view, I - segment IX dorsal view, J - segment IX ventral view. A - scale 1, B-J - scale 2. la - lateral apotome.



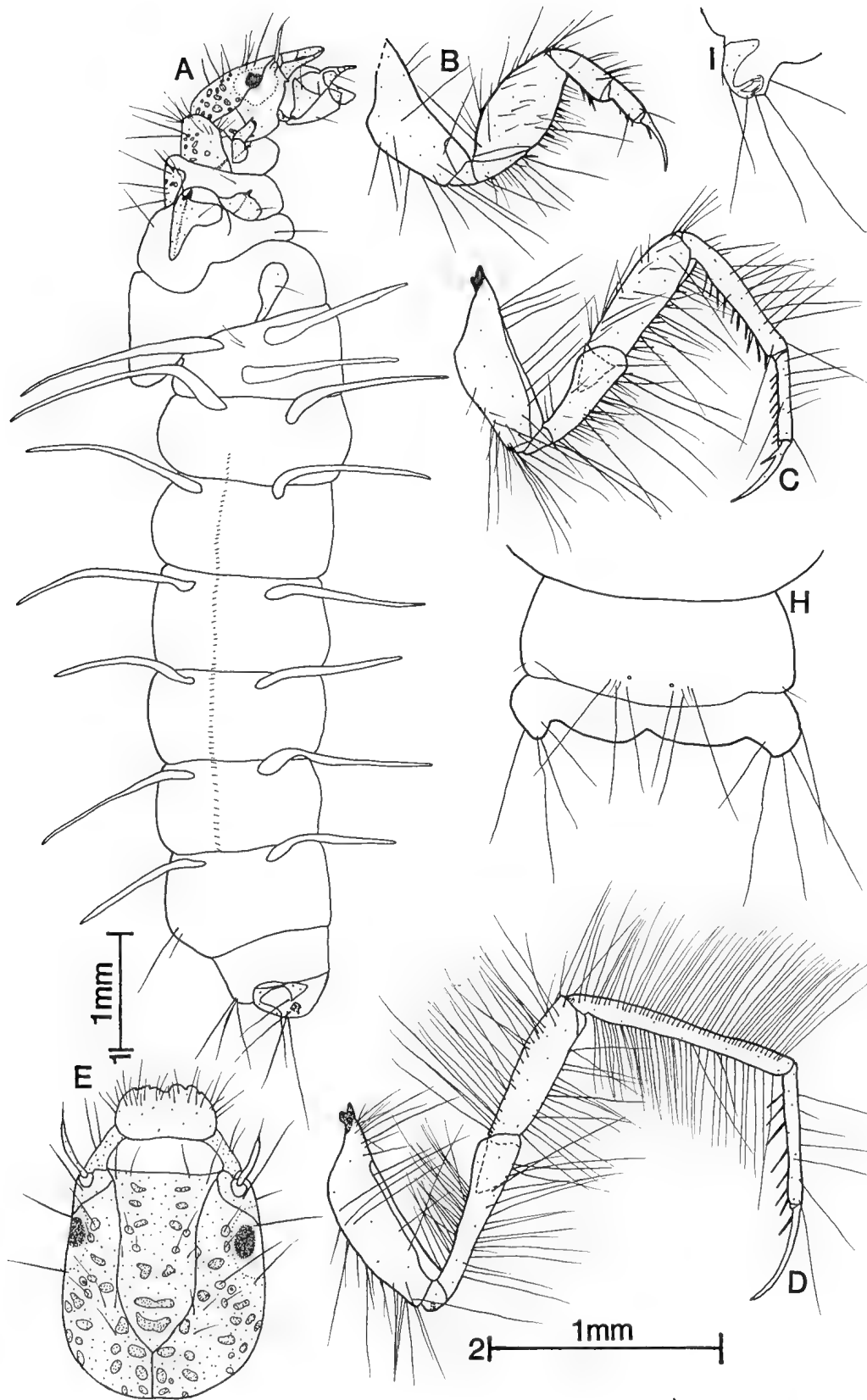


Fig. 23. *Oecetis laustra* larva (PT-917). A - body lateral view, B - right foreleg, C - right midleg, D - right hindleg, E - head dorsal view, F - head ventral view, G - thorax dorsal view, H - segment IX dorsal view, I - anal proleg. A - scale 1, B-I - scale 2.

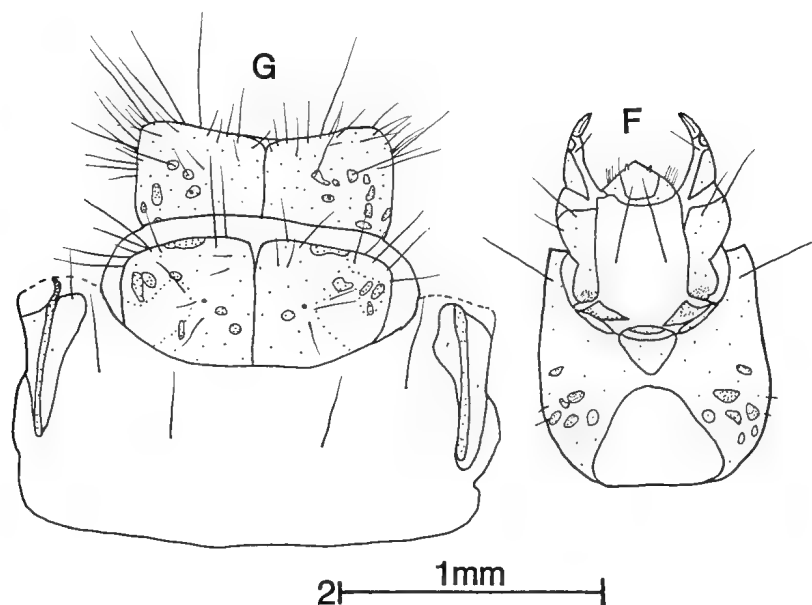


Fig. 23 cont'd.

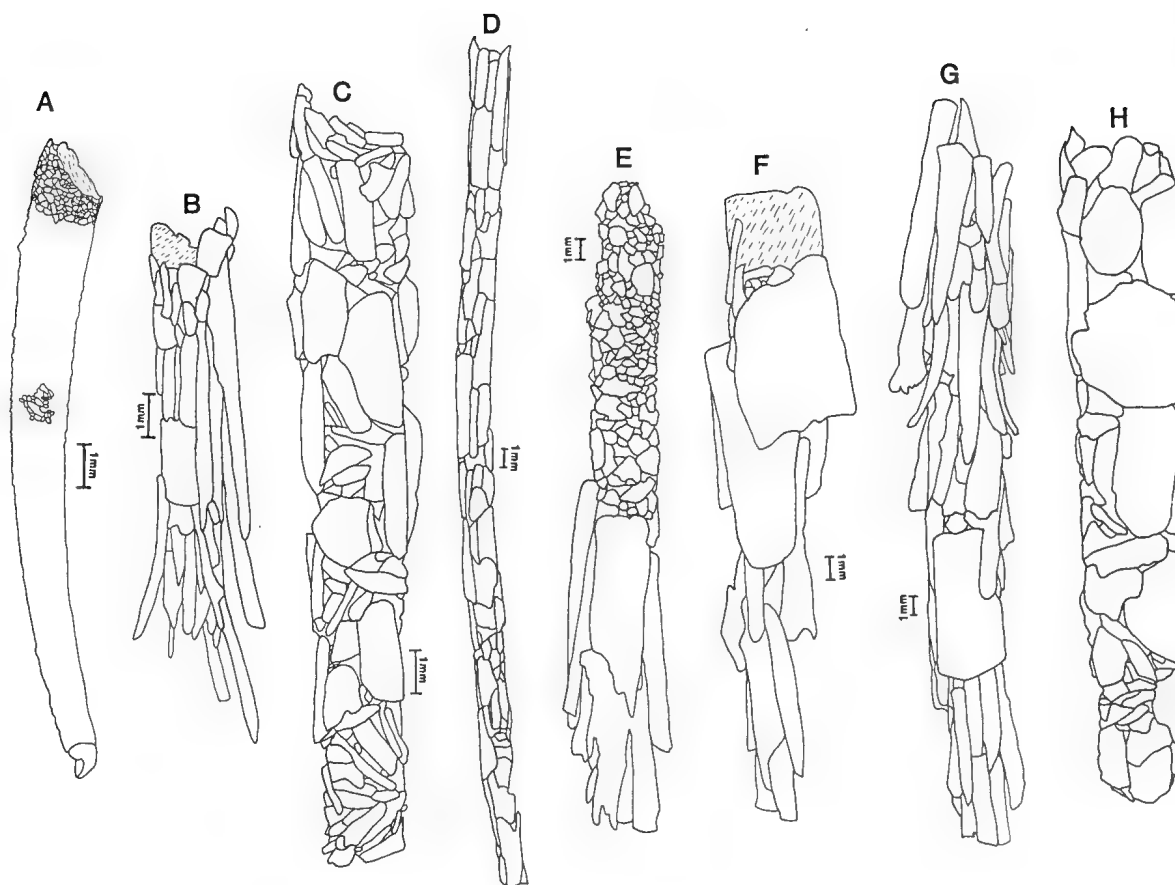


Fig. 24. Larval cases. A – *Triplexa villa*, B – *Condocerus paludosus* (PT-910), C – *Notoperata maculata* (PT-954), D – *N. sparsa*, E-G – *Symphitoneuria opposita*, H – *Triplectidina nigricornis* (PT-952).

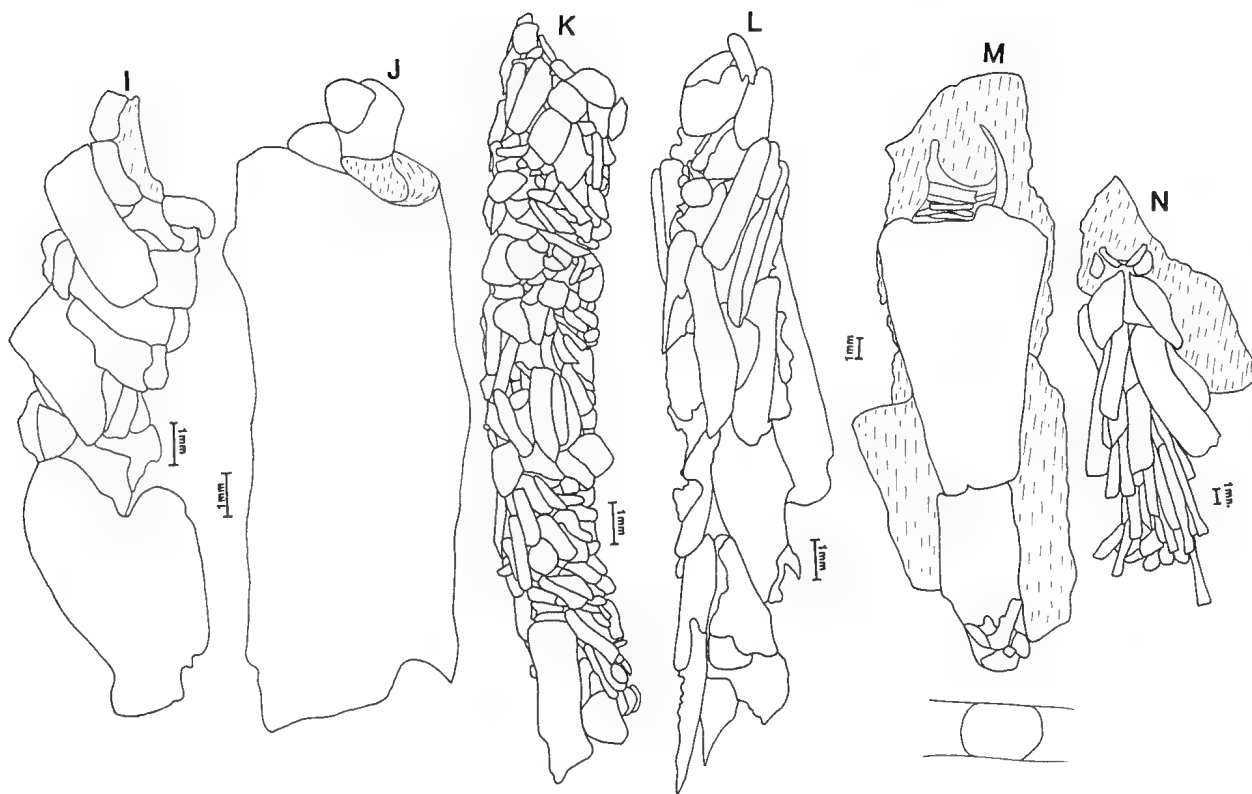


Fig. 24 cont'd. I - *Triplectides similis*, J - *T. proximus*, K - *T. varius*, L - *T. truncatus* (PT-943), M - *T. altenogus* (with diagrammatic cross section), N - *T. australis*.

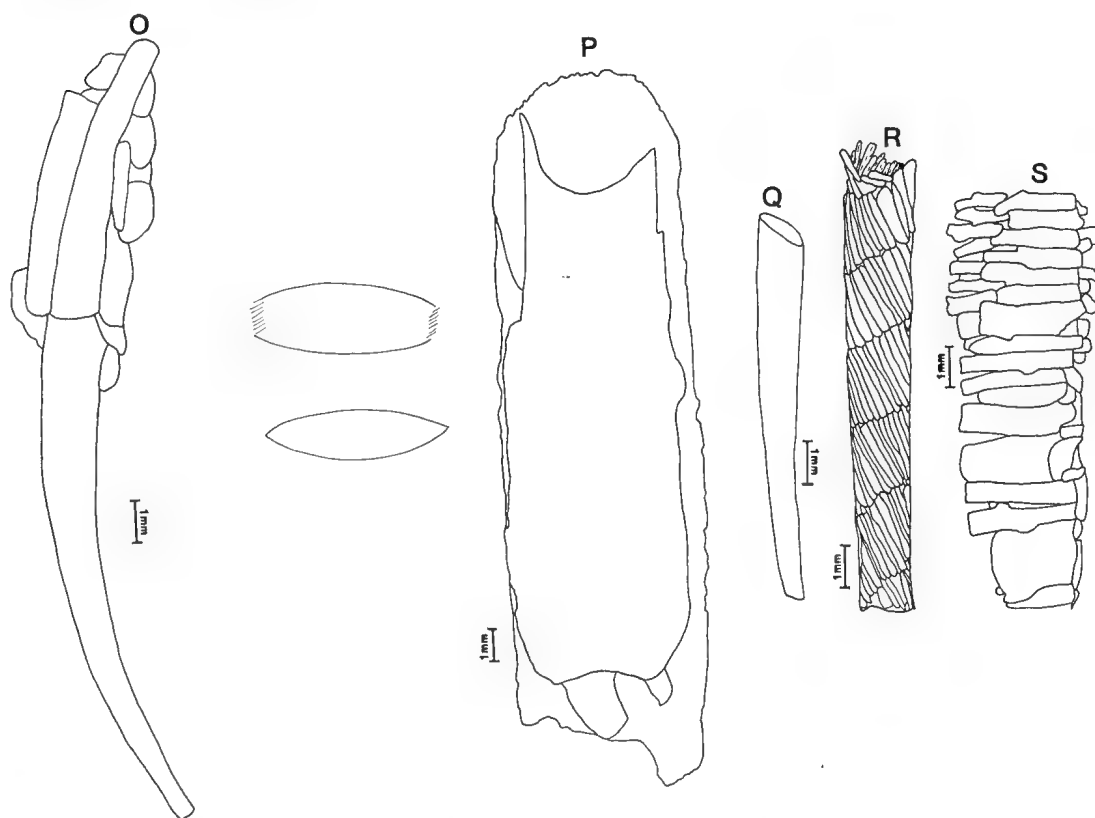


Fig. 24 cont'd. O - *Triplectides volda*, P - *Westriplectes pedderensis* (with diagrammatic cross sections of other cases), Q - *Leptocerus souta*, R - *Triaenodes volda* (PT-928), S - *Oecetis laustra* (PT-917).

*Oecetis laustra* Mosely

Figs 3C, 23, 24S

**Material examined.** Three reared males, 5 reared females and 14 larvae. VICTORIA: Bungallally Creek, 4 km south of Horsham, A. Sokol, 5 Feb. 1986, 1; Warrambine Creek, 5 km south-west of Inverleigh, 27 Jan. 1985, 1; Shaws Lake at Blackwood, 15 Nov. 1985, 1; Patterson Lakes Melbourne, K. Ough, 4 Aug. 1982, 1; swamp in Stratford Highway Park, 16 Nov. 1983, 2 males (incl. PT-947), 4 females (incl. PT-889), 6 (incl. PT-917); Lake Bunga, 3 km east-north-east of Lakes Entrance, 15 Oct. 1982, 1 male, 1 female, 2; Genoa River at Genoa, 13 Oct. 1982, 1.

**Description.** *Head.* Width 0.72-0.88 mm (n=8); approximately square dorsally; pale yellow with brown spots, back of head on each side with strip without spots; paler ventrally; frontoclypeal apotome posteriorly with 4 spots or some of these merged to form 2 bars or 1 bar and 2 spots; pale patch around eye faint; antennae long, over half length of frontoclypeal apotome at anterior margin; frontoclypeal apotome long, sides fairly straight.

*Thorax.* Pronotum pale yellow with brown spots; mesonotum very pale yellow, white at sides, with brown spots; metanotum with 2 pairs of setae; foretrochantin blunt with short finger-like projection dorsally; metasternum with 2 setae (1 larva with 1 on one side and 3 on other); legs very pale yellow; foreleg comparatively long and thin; hindleg with 2 long setal fringes 180 degrees apart on femur, tibia and tarsus.

*Abdomen.* Lateral hump sclerites very pale, gills long and thin arranged as in diagram in table 1; tergite IX not apparent; lateral sclerite and ventral sole plate pale yellow, small; anal claw small, with 3 accessory hooks on outer margin.

*Body length.* 4-7 mm.

*Case.* Made of thin green rectangular strips of macrophyte arranged in tapering 4 sided box (Fig. 24S). Posterior end blocked with silk membrane with small central hole or slit. Case usually not much longer than larvae. This case type used by other species of *Oecetis*.

**Habitat and distribution.** Larvae were found in lakes, swamps, estuaries and sluggish streams, usually associated with macrophytes. This species has previously not been recorded from Victoria but occurs in Western Australia, Queensland and Tasmania (Neboiss, 1983).

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## APPENDIX

Table 1. Gill diagrams. Eight rectangles represent the first 8 abdominal segments, with the line bisecting the rectangles representing the lateral midline of the larva. The first segment is to the left. Numbers in the boxes refer to the number of gill filaments and the positions of the numbers represent the positions of the gills on the segment.

*Notoperata maculata*

1	1	1	1	1	1		
	1	1	1	1			
	1	1	1	1	1		

*Lectrides varians*

0-1	1	1	1	1	1	0-1	0-1
	1	1	1	1	1	0-1	
	1	1	1	1	1	0-1	0-1

*Triplectidina nigricornis*

1	1	1	1	0-1	0-1	0-1	
	1	0-1	0-1				
	1	1	1	0-1	0-1		

*Triplectides proximus*

	1	1	1	1	1	1	
		1	1	1	0-1		
	1	1	1	1	1	0-1	

*T. elongatus* range

	1	1	1	1	0-1	0-1	
	1	1	1	1	0-1		
	1	1	1	1	1	0-1	

*T. truncatus* range

	1	1	0-1	1	1		
		0-1	1	0-1	0-1		
	1	1	1	1	1	0-1	

*T. altenoquus*

	1	1	1	1	1	0-1	0-1
	1	1	1	1	1	0-1	0-1
	1	1	1	1	1	1	1

*T. ciuskus*

0-1	1	1	1	1	1	1	0-1
	1	1	1	1	1	1	0-1
0-1	1	1	1	1	1	1	0-1

*T. volda*

0-1	1	1	1	1	1	1	0-1
	1	1	1	1	1	0-1	
0-1	1	1	1	1	1	0-1	0-1

*Westriplectes pedderensis* range

1	1	1	1	1	1	1	1
	1	1	1	1	0-1	0-1	
1	1	1	1	1	1	1	0-1

*Leptorussa darlingtoni*

3	3	3	2-3	2-3	2-3	1-3	0-2
	0-3	1-2	0-4	0-1	0-1		
3	2-3	3	2-3	2	1-2	0-2	

*N. sparsa*

	1	1	1	1	0-1		
	1	1	1	1	0-1		
	1	1	1	1	0-1		

*Symphitoneuria opposita*

1	1	1	1	1	1	1	0-1
	0-1	1	1	0-1	0-1	0-1	
1	1	1	1	1	1	1	0-1

*Triplectides similis*

1-3	4	4	3-4	3-4	3-4	2-4	1-3
	1-3	2-3	1-3	1-2	0-3	0-2	
0-3	3-4	3-4	3-4	3-4	2-3	1-3	1-2

*T. varius*

	1	1	1	1	1		
	1	1	1	1	0-1		
1	1	1	1	1	1	0-1	0-1

*T. elongatus* most common

	1	1	1	1	1		
	1	1	1	1			
	1	1	1	1	1	1	

*T. truncatus* most common

	1	1	1	1	1		
		1	1	1			
	1	1	1	1	1		

*T. australicus*

0-1	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
0-1	1	1	1	1	1	1	1

*T. australis*

1	1	1	1	1	1	1	1
	1	1	1	1	1	1	0-1
1	1	1	1	1	1	1	1

*T. magnus*

1	1	1	1	1	1	1	1
	1	1	1	1	1	1	0-1
1	1	1	1	1	1	1	1

*W. pedderensis* most common

1	1	1	1	1	1	1	1
	1	1	1	1	1		
1	1	1	1	1	1	1	1

*Oecetis laustra*

	1	1	1	1	1	1	1
	1	1	1	1	1	1	1
	1	1	1	1	1	1	1

## A Revision of the Genus *Mediomastus* Hartman, 1944 (Polychaeta: Capitellidae)

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**ABSTRACT.** The genus *Mediomastus* is redefined, and nine species are recognised. Three of these are new species, and one, *M. deductus*, is transferred from the genus *Heteromastus*. Three further species probably belong in *Mediomastus* but there is insufficient information available to confirm this. Two further species originally placed in *Mediomastus* are shown to belong in other genera. A full description of each species is given, based upon the re-examination of type material. Two tables indicating all the relevant diagnostic characters of all described species of *Mediomastus* are given. Comments are made on the validity of the characters that have been used traditionally in capitellid taxonomy. Setal characteristics are the most diagnostic and these should be examined by SEM as well as by light microscopy. However, identification of species of *Mediomastus* requires a combination of diagnostic characters.

WARREN, L.M., P.A. HUTCHINGS & S. DOYLE, 1994. A revision of the genus *Mediomastus* Hartman, 1944 (Polychaeta: Capitellidae). Records of the Australian Museum 46(3): 227–256.

Hartman (1944) erected the genus *Mediomastus* with the following characteristics, a thorax of 11 segments, including a well-developed asetigerous peristomial ring; segments 2 to 5 with capillary setae and segments 6 to 11 with hooded hooks. *Mediomastus californiensis* Hartman was designated as the type species. This genus has been well accepted and nine additional species have subsequently been assigned to it.

The original description of *Heteromastus filiformis* (as *Capitella filiformis*) by Claparède (1864) referred to

ten thoracic segments, the first four with capillary setae and the following six with hooded hooks, which conforms to the above definition of *Mediomastus*. However, according to Eisig's (1887) original diagnosis of *Heteromastus*, there are 11 thoracic setigers, of which the first five have capillary setae. This definition has been followed by all subsequent workers. Hutchings & Rainer (1981) designated a neotype of *Heteromastus* in accordance with Eisig's definition, to legitimise the use of *Heteromastus* Eisig. Hutchings



& Rainer (1981) have thereby also eliminated the potential confusion between these two common genera.

*Mediomastus* occurs commonly in intertidal and shallow subtidal environments and is frequently collected in ecological surveys. The identification of the genus appears to cause difficulties as the individuals are small (3-31 mm in length and 0.3-1.0 mm in width) and have few obvious characters. Determination to species level has been difficult partially as the current species' descriptions are often inadequate. Recently, large populations of *Mediomastus* have been found throughout Australia. While attempting to identify the material it became apparent that additional morphological characters were needed to satisfactorily separate species within this genus. In this revision of the genus all species are redescribed, together with the description of three new species. Species originally described as belonging to the genus but currently assigned to other genera, are also considered.

Within the family Capitellidae the number of thoracic segments and the arrangement and type of setae (thoracic setal formula) have been the primary generic diagnostic characters. These have formed the basis for identification keys and charts (Fauchald, 1977; Amaral, 1980). Recently there has been a proliferation of monospecific genera based on these two characters; however, in many cases it appears that there is no clear external boundary between the thorax and the abdomen and often the material is not mature. This is important as in some genera the number of thoracic setigers with capillary setae increases with age and juvenile worms cannot, therefore, be reliably assigned to a genus using this character (George, 1984; Warren & George, 1986). This phenomenon we suspect is widespread within the family but, to date, the development of only a few species has been studied in detail. We therefore propose that the generic diagnosis of capitellid genera refer to the number of thoracic setigers with capillary setae occurring in adults and that considerable caution should be used in stating the total number of thoracic setigers in those genera in which the distinction between the thorax and the abdomen is indistinct. For some genera this may lead to a range in the number of thoracic setigers being given. We follow Warren (1991) in quoting the number of thoracic setigers rather than segments as has been done by earlier workers (Hartman, 1947). References to the presence or absence of an asetigerous peristomium have led to considerable confusion in the past because of the effect that this character has on thoracic segment counts and for this reason we have omitted it from the thoracic setal formulae, although the presence or absence of an asetigerous segment is still an important character. While the structure of thoracic and abdominal hooks may vary under the SEM the differences are not readily seen with light microscopy and therefore we have not included this in the generic diagnoses.

## Diagnostic Characters

A wide range of external characters has been used to differentiate species of capitellids. Large amounts of preserved material of some species of *Mediomastus* were available to us and we were able to undertake a detailed evaluation of the taxonomic utility of these external characters. However it must be stressed that several species of *Mediomastus* are currently known only from type material which could not be dissected or examined under the SEM. Although molecular studies may reveal additional species of *Mediomastus*, which are morphologically similar (cf. *Capitella*, Grassle & Grassle, 1976), such data could not be obtained for most species and therefore we have based our revision on external characters only. Our two tables of the diagnostic characters are designed to facilitate the identification of species of *Mediomastus* by benthic ecologists. A schematic diagram of an anterior portion of *Mediomastus* is given by Day (1967: 600, fig. 28.2n).

**Prostomium.** The size and shape of the palps have been used as diagnostic characters for species of *Mediomastus*. However variation due to fixation completely invalidates the use of this character when dealing with preserved material. This has been confirmed by Méndez & Cardell (1992) who have shown experimentally that the appearance of the prostomium in *Capitella* is strongly influenced by the method of fixation.

**Proboscis.** In all the material examined the proboscis is papillated; however, the number and size of papillae can be a useful character in some species, but only if the proboscis is everted, as it cannot be easily dissected.

**Peristomium.** The presence or absence of eye spots and their position on the peristomium is species specific; however, the eye spots often fade in alcohol and this feature should not be relied upon as a key character for species identification.

**Colour.** Alcohol preserved animals show no consistent colour patterns. In some species the abdomen or the entire animal is transparent. This is related to the development of the body wall musculature.

**Body shape.** The general body shape differs significantly between species. In some species the thorax is widest at setiger 2 or 3, in others the thoracic setigers are all more or less the same width. The abdomen may be coiled or nearly straight; this is species specific and does not appear to be significantly affected by method of preservation.

**Body size.** Total body length is a diagnostic feature, but is of limited use for identification purposes because complete worms are rarely collected, and individuals can regenerate lost abdominal segments. Thoracic length is

the most practical measure provided that the boundary between thorax and abdomen is clear. Thoracic width also gives an indication of size but the difference between the smallest and largest species of *Mediomastus* is so slight that this character is of no practical use.

**Size and shape of segments.** The ratio of length to width for segments in different body regions and the shape of the abdominal segments have been used in species diagnoses. Both these characters are highly variable however, and are dependent on the state of contraction, regeneration and the effects of fixation (Doyle, 1991).

**Presence of nephridiopores and lateral organs.** The anatomy of the nephridia can be diagnostic in polychaetes. For example, Hessle (1917) used the structure of nephridia as a means of distinguishing genera of terebellids and recently Smith (1992) has found consistent differences in the number and arrangement of nephridia in species of *Pista* (family Terebellidae). Nephridiopores and lateral organs have been described in some species of *Mediomastus* but these are difficult to see with confidence. Consequently we have not been able to evaluate their taxonomic significance.

**Thoracic setal formulae.** The presence of four capillary setigers is common to all species; all remaining thoracic setigers have hooded hooks only. The only differences in the thoracic setal formulae between species relate to the number of thoracic setigers (see Thorax/abdomen junction).

**Number of setae within fascicles.** The number of setae within a fascicle is size dependent but the relative numbers of capillary setae and hooks, and the number of setae in the notopodia relative to the number in the neuropodia can be a useful feature. However, this sort of analysis is dependent upon the availability of large amounts of undamaged material and we have only been able to determine these ratios in a few species. Therefore we are unable to state if the variation between species is greater than that occurring within a species.

**Structure of setae.** There are winged thoracic capillary setae in all species. The width of the wings varies both within and between species, but the variation between species is significantly greater. The structure of the hooded hooks varies between species and, although these differences can be seen under light microscopy, examination by SEM is recommended when describing a new species in order to clarify the structures observed under the light microscope. Differences exist between hooks present on the thorax and those on the abdomen; there can also be differences between the noto- and neuropodial hooks in the same setiger. Species vary in the length of the shaft; the presence or absence of a constriction and a shoulder; the proportions of the hood; the size and shape of the main fang; and in the arrangement of the teeth (Fig. 1). Figures 1a and 1b show

a generalised hooded hook from lateral and frontal view respectively. Some of the features identified are not apparent in all hooks and the proportions may differ. Figures 1c and 1d illustrate extreme forms within the normal range. Hooks can vary in the length and width of the shaft; the prominence of a proximal constriction and a distal shoulder; the proportions of the hood; the length of the fang and the arrangement of the teeth. Thoracic hooks, as in Figure 1d, are typically long and straight with no obvious shoulder and no constriction. The hood is long and tight fitting surrounding a small fang. In those species in which there is a difference between thoracic and abdominal hooks, the typical abdominal hook (Fig. 1c) is much shorter and stouter with a marked constriction and a definite shoulder. The hood is shorter but much more voluminous and the fang is much larger. In some species the hooks may be modified further by great elongation so that they appear superficially as spines (Fig. 1f). The presence of a hood, albeit very tight fitting, is often the best indication of the true nature of these setae. In two species, the detailed structure of the hooks is diagnostic. Thus the notosetal hooks in *M. acutus* appear bifid (Fig. 1e) and the abdominal hooks in *M. thomassini* n.sp. are curved downwards into a beak with the teeth stacked very steeply (Fig. 1g). The dental formula has been used in the past but we found it to be variable both within a row of hooks and along the body. Interpretation is also dependent on the orientation of the preparation making this a difficult character to use. We have, therefore, decided that it is of little use in a key for distinguishing between species in this genus.

In the species descriptions which follow the details of setal structure given are based upon in most cases on numerous setal mounts and the accompanying SEM photographs may not show all the details given in the text. Attempts to remove the hoods of the hooded hooks without damaging the underlying hook proved impossible, however sometimes in oil emersion mounts the hoods were partially damaged or accidentally had been removed during the preparation of the mount. Attempts to orientate the hooded hooks also proved impossible due to the small size of the setae. The SEM photographs of which only a selection are used in this paper often confirmed structures which could almost be seen under oil emersion. For all species examined with the SEM preserved material had to be used, only in the case of *M. australiensis* n.sp. was fresh material available which could be carefully collected in order to minimise contamination from fine particles which adhere to the mucous sheath which coats the animals. Cleaning of preserved material often resulted in damaging the fragile setae. As well as illustrating the setae with SEM photographs, highly schematic diagrams are provided to illustrate the diagnostic features of the setae but they should be used in conjunction with the SEM photographs. These schematic diagrams do not illustrate the often highly textured surface of the hood.

**Thorax/abdomen junction.** Members of the genus are

typically described as having ten thoracic setigers. In some species, however, it is difficult to determine the exact number of thoracic setigers. This may be because there is no abrupt change of function between the thoracic and abdominal setigers. The following characters are different in thoracic and abdominal segments – body wall musculature, gut, hook structure and position, development of parapodial ridges (Hartman, 1947). The setiger on which the change occurs, however, is not necessarily the same for each of these characters (although it is consistent within a species), so that it is not possible to see where the thorax ends and the abdomen begins. In most species, it is possible to see a distinct discontinuity at low magnification. This is because the intersegmental groove at the thorax/abdomen boundary is deeper than those between other segments. If picked up, the specimen may bend at this point. More detailed examination may reveal the transitional mix of characters listed above. For the purposes of the descriptions, however, the intersegmental groove is taken to be the boundary, and references to the boundary being distinct or indistinct refer to this feature.

**Asetigerous segments.** In some species the number of asetigerous segments immediately anterior to the pygidium has been indicated. However, examination of a wide range of material of some species shows that the distribution of setae in extreme posterior segments is highly variable especially as many specimens have regenerated posterior ends, which initially lack setae.

**Branchiae.** Parapodia on posterior segments can be swollen and may have a respiratory function but no physiological investigation of their role has been undertaken.

**Caudal cirrus.** In all species the pygidium is terminal with a midventral caudal cirrus the length of which is of diagnostic value. The cirrus is easily detached, leaving no obvious scar, and is contractile.

**Egg diameter.** Morphologically similar species of *Capitella* differ in the number and size of eggs produced. This is related to reproductive strategy. Within a species of *Capitella*, sizes are usually consistent. Overall, the genus *Mediomastus* exhibits less variation in egg diameter than in the genus *Capitella*, and egg diameter is diagnostic for a particular species of *Mediomastus*.

**Methyl green staining.** Ewing (personal communication) has used this staining technique to distinguish between species of *Mediomastus* in the same sample but to date the technique has not been rigorously tested. We suspect that fixation and preservation may influence the staining patterns observed and comparisons should only be made between individuals subjected to identical fixation and preservation. Furthermore, the technique is only of use for small worms where the body wall is relatively thin so that the stain can be viewed using transmitted light. With larger

species such as *M. fragilis* and *M. deductus*, it is impossible to detect bands of stain.

We did, nonetheless, submit specimens of a number of species to this treatment during the course of this study. In each case preserved worms (previously fixed in formalin but now stored in alcohol) were placed in a weak solution of methyl green in 70% alcohol (prepared by sprinkling a few grains of the powdered stain on to the surface of the liquid) for one or two minutes until the whole surface of the worms had taken up the stain. The worms were then rinsed in several changes of alcohol and observed under a dissecting microscope at regular intervals as the stain was progressively washed out. The colour is not lost evenly and gradually prominent bands of colour, sometimes in the form of dots (presumably indicating the presence of glandular cells) are all that remain. This colour pattern was recorded on a chart as shown in Figure 2. Only the staining bands on the posterior part of the thorax have been indicated in Figure 2. In some species there may be fainter bands around anterior setigers, especially setiger 2 but these are not consistent and fade very quickly. Density of stain is indicated by the closeness of the shading lines. For those species in which the staining is restricted to dots in some places, this is indicated by dots on the figure. There may be considerable individual variation, especially in the number of setigers stained. The diagrams are based upon individual worms considered representative of the species rather than a composite picture covering all variations for the species. Numbers refer to setigers.

**Habitat.** While all species occur in soft sediments, the precise requirements are largely unknown.

**Locality.** Because the geographical range of each species is unknown, the locality cannot be used as a reliable character for species identification. It can, however, provide an indication as to the likely species. The known distributions of each species are given in Figure 12.

**Summary of character utility.** The most decisive character is the setal structure. There is little individual variation and treatment of the specimen has no effect on the morphology as viewed with light microscopy. It is not, however, easy to use. Setae are small and orientation may be difficult. Some features can only be detected with confidence using the SEM. For this reason, it is necessary to make additional use of some of the other characters. Using a combination of diagnostic characters it should be possible to identify specimens to species level using Tables 1 and 2 (Appendix) which contain the diagnostic characters of the species of *Mediomastus*. We considered this approach preferable to the more conventional dichotomous key using one or two diagnostic characters at each stage. This would have been unworkable, partly because specific variations in each character are so slight and partly because of the common occurrence of incomplete worms.

**Abbreviations.** The following abbreviations have been used in the text: LACM-AHF – Allan Hancock Foundation, Los Angeles (collection now housed in The Los Angeles County Museum); AM – The Australian Museum, Sydney; BMNH – British Museum (Natural History), London; CAS – California Academy of Sciences, San Francisco; HZM – Zoologisches Institut und Zoologisches Museum der Universität, Hamburg; MNHN – Museum National d'Histoire Naturelle, Paris; NMWZ – National Museum of Wales, Cardiff; RSM – Royal Museum of Scotland, Edinburgh; SAM – South African Museum, Cape Town; USNM – United States National Museum, Washington.

SEM – scanning electron microscope.

Tables 1 and 2 are listed in the Appendix.

## Taxonomy

### Generic Diagnosis

#### *Mediomastus* Hartman

*Mediomastus* Hartman, 1944: 264.–Hartmann-Schröder, 1962:

143, fig. 119e.–Fauchald, 1977: 34.

*Capitita* Hartman, 1947: 408–409.

**Diagnosis.** Body small and thread-like consisting of numerous setigers. Abdomen often highly coiled and posterior setigers often bell-shaped. Prostomium with elongated, round-tipped palpode. Proboscis eversible with papillae. Peristomium asetigerous with or without eye spots. Thorax of 9–11, usually 10 setigers of which the first 4 bear winged capillary setae in both noto- and neuropodia; subsequent thoracic setigers with long-shafted hooded hooks in both noto- and neuropodia. Junction between the thorax and abdomen may or may not be distinct. Number of abdominal setigers variable with size and age. Abdominal setigers with hooded hooks and sometimes with long capillary setae in notopodia of posterior segments. Abdominal hooded hooks structurally different from thoracic hooks although differences may be slight. Modified paddle-like setae sometimes present. Pygidium terminal with midventral caudal cirrus.

**Type species.** *Mediomastus californiensis* Hartman, 1944 by original designation.

**Comments.** We have modified the generic diagnosis of *Mediomastus* to accommodate species which we consider to belong in the genus and yet do not have a clear demarcation between the thorax and abdomen. Included, are species having nine or ten thoracic setigers with setiger 10 being transitional, and one species, *M. fragilis*, in which setiger 11 shows some features typical of anterior setigers. The generic diagnosis has been expanded to include the fact that structural differences occur in the hooded hooks, and that modified paddle-

like notosetae as found in *Mediomastus acutus* may be present.

The original diagnosis of the genus *Mediomastus* has been modified several times since Hartman (1944) erected the genus. Hartman (1960) expanded the definition to include a new species, *Mediomastus glabrus*, which has the first four to six thoracic setigers with capillary setae and the last six to four thoracic setigers with hooded hooks. Hartman (1969) subsequently removed *M. glabrus* from *Mediomastus* and erected a new genus, *Neomediomastus* for this species; and the original generic diagnosis of *Mediomastus* was reinstated. Hartmann-Schröder (1959) enlarged the generic definition to include species with ten thoracic segments and simple notopodial setae in posterior abdominal segments. In 1962, she reverted to Hartman's (1944) original generic definition of 11 thoracic segments, at the same time expanding the diagnosis to include species with branchiae. Hartmann-Schröder also synonymised the genus *Capitita* Hartman, 1947, with *Mediomastus*. Fauchald (1977) however, while agreeing with this synonymy, repeats Hartman's (1944) definition of *Mediomastus* and this is still widely used.

We have looked at all the available type material of species that are presently, or have been, included in the genus *Mediomastus*, and conclude that there are at least nine valid species, including three newly described ones. Type material of three of the species was in such poor condition or so incomplete that we are unable to comment on their status. Two species do not belong to *Mediomastus*. The status of each species may be summarised as follows:

*Mediomastus acutus* Hartman, 1969

*Mediomastus ambiseta* (Hartman, 1967) – original genus  
*Capitita*

*Mediomastus australiensis* n.sp.

*Mediomastus branchiferus* Hartmann-Schröder, 1962  
*species inquirenda*

*Mediomastus californiensis* Hartman, 1944

*Mediomastus calliopensis* n.sp.

*Mediomastus capensis* Day, 1961

*Mediomastus caudatus* Hartman, 1974 – removed to  
*Heteromastus*

*Mediomastus cirripes* Ben-Eliahu, 1976 – *species inquirenda*

*Mediomastus deductus* (Pillai, 1961) – original genus  
*Heteromastus*

*Mediomastus fragilis* Rasmussen, 1973

*Mediomastus glabrus* Hartman, 1960 – removed to  
*Neomediomastus*

*Mediomastus setosus* Hartmann-Schröder, 1959 – *species inquirenda*

*Mediomastus thomassini* n.sp.

#### *Mediomastus acutus* Hartman

Figs 1e, 3a–f, 4a–f, 5a–c, 12; Tables 1, 2

*Mediomastus acutus* Hartman, 1969: 385, figs 1–3.

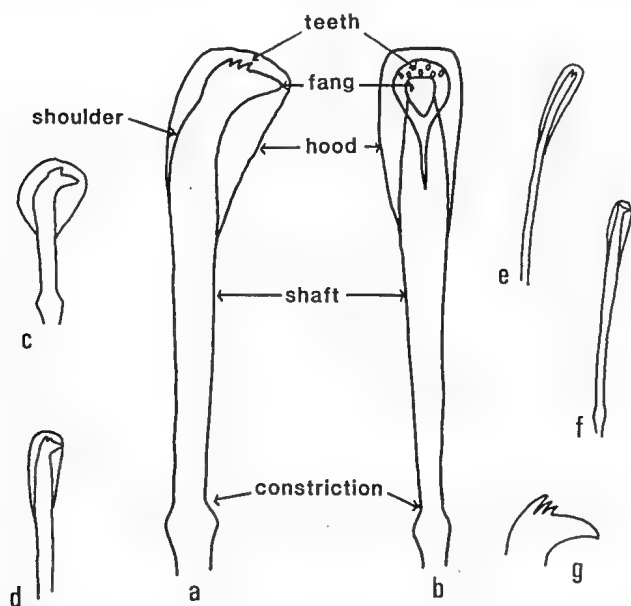
**Type material examined.** HOLOTYPE (LACM-AHF 6731-59, Poly 0451), PARATYPE (LACM-AHF 6731-59 Poly 1327) 5.2 km from Ventura Pier light, California, USA, 34°17'53"N 119°21'05"W, 6 Dec. 1959, 9 m, fine silty sand, both incomplete, holotype female.

**Additional material.** USA – 4.4 km from Standard-Humble oil platform, 34°23'02"N 119°30'40"W, several, mounted for SEM examination (LACM-AHF 6721-59) 4 Dec. 1959, 10 m; Imperial Beach, 32°28'N 117°08'W (LACM-AHF) 28 Aug. 1984, 9 m, complete, 17.5 mm long and thorax of 2.5 mm long and 0.25 mm wide.

**Description.** Holotype lacks anterior end and consists of only a few abdominal segments and lacks caudal cirrus. Paratype consists of single posteriorly incomplete specimen with thorax and 23 abdominal segments; 4 mm in length; no coelomic gametes visible. As the non-type material closely resembles the incomplete type material this description is a composite one. Detailed information on setal structure was obtained from AHF 6721-59 examined under SEM, which was collected from close to the type locality for the species. Alcohol preserved material pale cream.

Thread-like, with abdomen loosely coiled. Thorax abdominal boundary distinct between setigers 10 and 11. Prostomium long and pointed with elongated, pointed palpode. Eversible proboscis with poorly developed papillae. Peristomium with or without eye spots.

Thorax with 10 setigers; maximum width at about setiger 2-3; from setiger 6 segments markedly biannulated and about half as long as wide (Fig. 3a). Nephridiopores not seen.

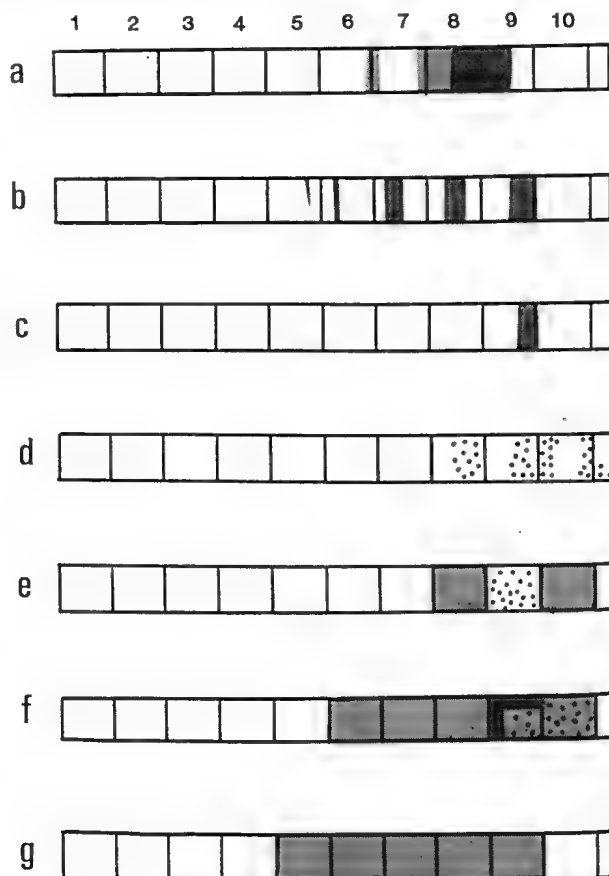


**Fig. 1.** Structure of the hooded hooks: a – generalised hooded hook, lateral view; b – generalised hooded hook, frontal view; c – typical abdominal hooded hook; d – typical thoracic hooded hook; e – *Mediomastus acutus* notosetal “hook”; f – *M. ambiseta* abdominal “spine-like” hook; g – *M. thomassini* n.sp. abdominal hooded hook.

Setigers 1-4 with expanded winged capillary setae (Figs 3b, 5a), setigers 5-10 with hooded hooks in neuropodia (Figs 3c, 4b) and hooded hooks in notopodia of setigers 5-7 (Fig. 4a) and modified paddle-like notosetae on setigers 8-10 (Figs 3d, 4c,d, 5b). Notosetae and neurosetae in 4 equally spaced fascicles at mid-segment level on setigers 1-7 (Fig. 4e). From setiger 8 the 2 notopodial rami merge to form a single mediodorsal notopodia (Fig. 4f). In addition all fascicles on setiger 10 inserted more posteriorly than preceding ones. Paratype with 5-6 capillary setae per fascicle and 3-5 hooded hooks per fascicle.

Capillary setae appear short-shafted, winged, spatulate-like with smooth tips (Fig. 3b). Notosetae of setigers 6-7, long-handled hooks (Fig. 4a). From setiger 8 onwards the notosetae appear bifid under light microscopy (Fig. 1e). However under SEM, the structure of these notosetae appears as follows, base of hood elongated proximally with the side of the hood flared and enrolled around shaft; instead of a hook there is an acicular type seta almost concealed by flared hood (Figs 3d, 4c,d, 5b). Thoracic neurosetae shorter, hooded hooks, hood not extended proximally (Figs 3c, 4b, 5c).

Abdomen with anterior segments rounded in cross



**Fig. 2.** Methyl green staining: a – *Mediomastus ambiseta*, Buzzards Bay, Massachusetts; b – *M. californiensis* type; c – *M. capensis* type; d – *M. thomassini* n.sp. type; e – *M. calliopensis* n.sp. type; f – *M. cirripes* type; g – *M. australiensis* n.sp. type.



section, posterior segments markedly bell-shaped. Pygidium smooth ring with short caudal cirrus. Setiger 11 with 8 setae per fascicle in both noto- and neuropodia, setiger 21 with 5-6 setae per fascicle in notopodium and 13 in neuropodium, extreme posterior setigers with 1-2 setae. Abdominal neurosetal hooks resemble neurosetal thoracic hooks (Fig. 3f). Anterior abdominal setigers initially have a fused notopodium with paddle-like notosetae (Fig. 3e). However there is some evidence on the material available to us, for SEM examination, that posterior abdominal segments have 2 notopodia, only one of which has paddle-like notosetae. It was not possible to determine exactly where the single notopodium splits into the typical 2 notopodia.

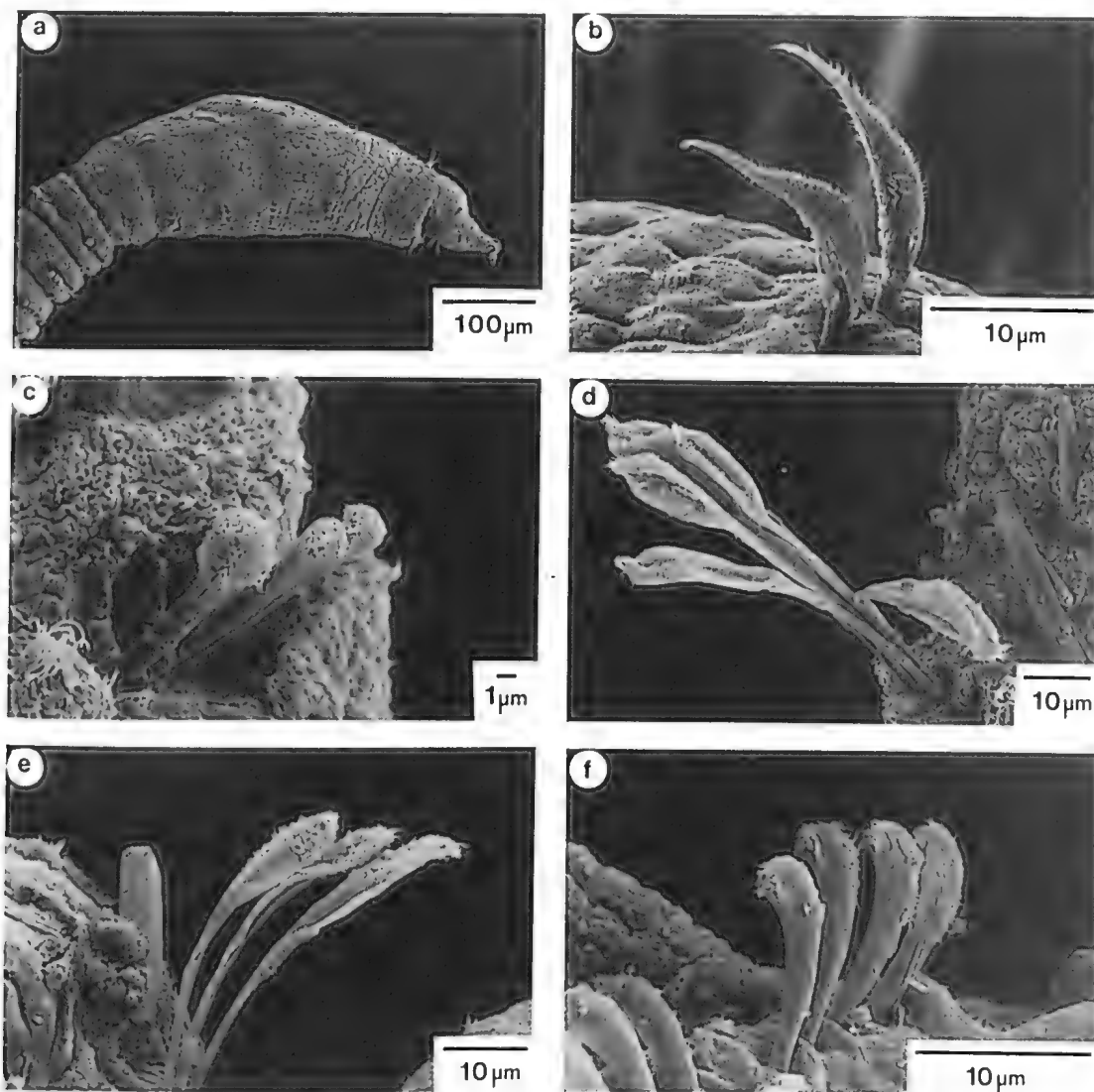
Gravid female (Imperial Beach) with coelomic oocytes of 60  $\mu\text{m}$  in diameter.

**Comments.** The presence of paddle-like notosetae has not previously been reported in *Mediomastus* and

necessitates a modification to the generic diagnosis. It is not surprising that these type of setae have not previously been reported as it is only when these setae are examined under the SEM that this paddle-like structure can be observed. Under light microscopy they appear as partially bifid structures. The presence of a single fused notopodium in anterior abdominal setigers is a unique feature in this species.

**Habitat.** Type locality is 9 m in very fine silty sand and other specimens have been collected from fine sand sometimes among onuphid (*Diopatra*) tubes. The species has also been reported in shallow seagrass beds of *Zostera marina* (Harris, personal communication).

**Distribution.** Species known only from California, USA, (34°23'02"N 119°30'40"W to 32°28'N 117°08'W) (Fig. 12).



**Fig. 3.** *Mediomastus acutus*: a – prostomium and anterior thoracic segments; b – thoracic setiger 1 showing capillary setae; c – thoracic neurosetae setiger 10; d – thoracic notosetae setiger 10; e – notosetae setiger 32; f – neurosetae setiger 31-32.

*Mediomastus ambiseta* (Hartman)

Figs 2a, 5d–f, 6a–f, 12; Tables 1, 2

*Capitita ambiseta* Hartman, 1947: 409–410, pl. 45, figs 1–4.  
*Mediomastus ambiseta* Hartmann-Schröder, 1962: 143, fig. 18.

**Type material examined.** HOLOTYPE (LACM-AHF 1451-42, Poly 0499), PARATYPES (LACM-AHF 1451, Poly 0450), Newport Harbour, Corona del Mar, California, USA, 33°36'04"N 117°52'48"W, 2 June 1942, intertidal.

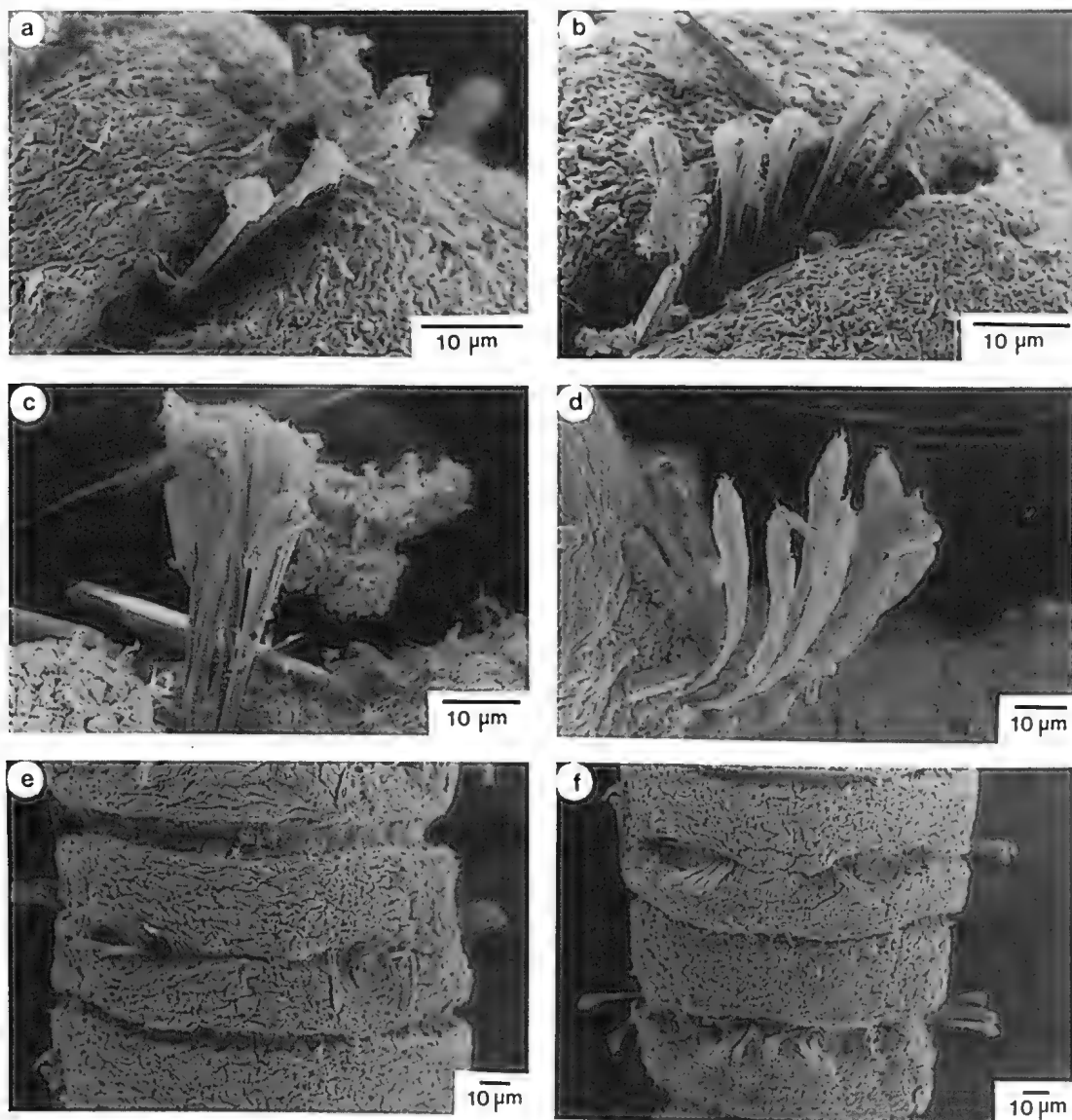
**Additional material.** USA – Newport Bay, north, 33°36'58"N 117°54'12"W to 33°37'12"N 117°53'25"W, (LACM-AHF 1442–41) intertidal, sandflats along shore, mounted for SEM examination; Oxnard Beach, 34°11'N 119°15'W, 1 (LACM-AHF) A36, Sept. 1974, 30 m; Ace Mission Bay, 32°47'N 117°15'W, 4 (LACM-AHF) St.B.9.IV, 6 June 1980; San Diego Bay, 32°45'N 117°10'W, 3 (LACM-AHF) Aug. 1986, 3 m; northern Monterey Bay 36°53.6'N

121°57.5'W, 1 (CAS 0513 Cat 005168) 34.5 m; Massachusetts, Buzzard Bay, 41°30'N 70°53'W, 9 (AM W12045) 20 m; Outer New Bedford Harbour, 41°40'N 70°50'W, 4 (BMNH ZB 1990 53–56).

**Description.** Holotype consists of anterior thorax, connected to few abdominal segments by poorly preserved strand, far posterior segments and caudal cirrus absent. Paratypes consist of 5 anterior fragments, 3 midabdominal fragments and an extreme posterior fragment with caudal cirrus.

This description is based, in part, on non-type material collected from southern California which is the type locality. The east coast material from Massachusetts compares closely with this material.

Body length to 14 mm; length of thorax to 1.1 mm; width of thorax to 0.15 mm; up to about 70 segments. Thread-like; abdomen highly coiled. Thorax/abdomen boundary distinctive. Setigers 5–9 all of similar shape and size; setiger 10 shorter and narrower. Abdominal setigers



**Fig. 4.** *Mediomastus acutus*: a – thoracic notosetae setiger 6; b – thoracic neurosetae setiger 7; c – thoracic notosetae setiger 9; d – thoracic notosetae setiger 10; e – thoracic setiger 6 showing four rami; f – thoracic setigers 7 and 8 with the notopodial rami merging and the beginning of paddle-like notosetae at setiger 8.



much paler. From setiger 11 segments thin walled and variable in shape, often with prominent ventral gutter. Colourless and transparent in alcohol. Methyl green staining on posterior of setigers 6 and 7, setiger 8 and anterior of 9; strongest staining on posterior of setiger 8 and anterior part of setiger 9; weakest on 2 (Fig. 2a).

Prostomium small, conical with slightly elongated, round-tipped palpode. Eversible proboscis with low, indistinct papillae. Peristomium slightly longer than first thoracic setiger. Eyes not apparent.

Thorax of 9 setigers (Fig. 6a,b); setiger 10 may be transitional. Thoracic setigers half as long as wide; setiger 10 shorter and narrower. Epidermis of anterior thorax smooth, posterior setigers clearly biannulated. Shape of thorax variable, may be cylindrical or widest at setiger 5. Nephridiopores not visible. Setigers 1-4 with smooth, broadly winged capillary setae only; tips may be curved to form small hook. Setigers 5-9 with hooded hooks only. Setigers in 4 equally spaced fascicles at mid-segment level; no raised tori. Numbers of capillary setae per fascicle range from 2-7 in notopodia and 1-10 in neuropodia; hooded hooks number from 1-4 in notopodia and 2-6 in neuropodia. Thoracic hook straight with slight shoulder proximal to long neck; no constriction; small fang surmounted by 2 rows of teeth; tight fitting hood about 2.5 times as long as wide (Figs 5d, 6c).

Number of abdominal segments not fixed, commonly about 30 but may reach 70. Shape of abdominal segments varies; anterior abdominal segments about as long as wide; may decrease in posterior abdomen to 0.5 times width. Parapodial ridges more or less distinct at posterior margins of all segments except for setiger 10 where setae at mid-segment level. Branchiae absent. Pygidium a smooth ring with long midventral cirrus the length of which may reach 0.5 times thoracic length (Fig. 6f).

All abdominal segments with setae; no posterior asetigerous segments. Neuropodia with hooded hooks only, ranging from 5-10 per fascicle anteriorly to 2-6 posteriorly (Figs 5e, 6e). Notopodia with hooded hooks, ranging from 3-5 in anterior abdomen. Notopodial hooded hooks in mid-abdomen may be long and spine-

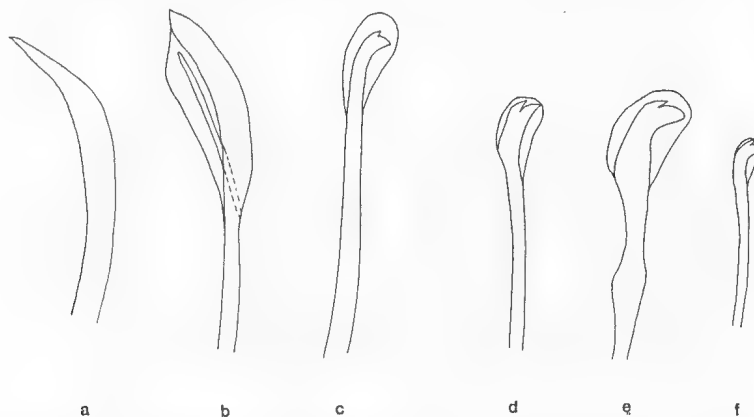
like (1 or 2 per fascicle); may be accompanied by single, long, unwinged capillary setae (Figs 5f, 6d). Posterior notopodia with 1-2 capillary setae per fascicle only. Abdominal setal formula varies considerably between individuals; spine-like hooks may be absent but usually begin on fifth to sixth abdominal segment; capillary setae begin on 12th-20th abdominal segment and may not be present on all segments posterior to their first appearance.

Neuropodial hooks short, stout, with prominent shoulder and constriction; large fang with at least 2 rows of minute teeth. Hood shorter and wider than in thorax; length about 2-3 times width. Hooks on anterior notopodia similar. Spine-like hooks are very elongated hooded hooks, much longer and slightly thinner than thoracic hooks; minute fang with very short, tight-fitting hood just visible under oil immersion. Abdominal capillary setae about 0.5 times width of spines and 1.5-2 times length; flexible or stiff, not winged.

Gravid females with large numbers of small eggs in coelom. Egg diameter 50  $\mu\text{m}$  or greater.

**Comments.** The material described differs from the type description in terms of the number of setae present per fascicle. Hartman (1947) describes four to six or more capillary setae present in the thoracic notopodia and three to six or more in the thoracic neuropodia with six to 11 thoracic hooded hooks per fascicle. However, the material examined exhibits considerable variation between individuals. The thorax/abdomen boundary is also different in the type material and the additional material examined here. Hartman (1947) describes ten thoracic setigers, of which the tenth is transitional, comparable in length to the thoracic setigers but with the setae positioned as in the abdominal setigers. The opposite is the case in the material examined. For further comments on this feature, see the discussion of diagnostic characters above.

**Habitat.** *Mediomastus ambiseta* occurs in shallow water and intertidally in mud and muddy sand. It may occur in clam beds. Hartman (1947) recorded it in



**Fig. 5.** Schematic figures of setae. *Mediomastus acutus*: a – modified winged capillary, lateral view; b – paddle-like notoseta, lateral view; c – neurosetal thoracic hooded hook, lateral view. *Mediomastus ambiseta*: d – thoracic hooded hook, lateral view; e – neuropodial abdominal hooded hook, lateral view; f – spine-like abdominal notopodial hooded hook, lateral view.

association with the spionids *Streblospio benedicti* Webster, 1879 and *Spiophanes missionensis* Hartman, 1941. It lives in a mucus tube vertically in the sediment; worms lie head downwards with the caudal appendage sticking out from the sediment.

**Distribution.** North America, west and east coasts (Fig. 12). Dauer & Simon (1976) record its presence in the Gulf of Mexico, however we have not examined this material to confirm the identification.

*Mediomastus australiensis* n.sp.

Figs 2g, 7a–b, 8a–f, 12; Tables 1, 2

*Mediomastus californiensis*.—Hutchings & Rainer, 1979: 779.—Hutchings & Rainer, 1980: 45.—Hutchings & Murray, 1984: 81.—Collett *et al.*, 1984: 124–125.—Day & Hutchings, 1984: 277.—non Hartman, 1944: 264–265, pl. 25, figs 64–65.

*Mediomastus* sp. Melbourne Metropolitan Board of Works *et al.*, 1973: 370.

*Mediomastus* sp. Hutchings & Recher, 1974: 105.

**Type material examined.** HOLOTYPE (AM W20589) complete, 21 mm long 1 mm wide, 95 setigers, gravid; PARATYPES 2 (USNM 136597) both complete, 20 mm long, 1 mm wide, about 72 setigers, gravid, 18 mm long, 1 mm wide, about 60 setigers; 2 (BMNH ZB 1994.4793–4794) both complete, 15 mm long, 1 mm wide, about 90 setigers, 21 mm long, 1 mm wide, about 90 setigers; 2 (LACM-AHF 1648) 20 mm long, 1.2 mm wide, about 145 setigers, 21 mm long, 1 mm wide, about 85 setigers with regenerated posterior end; 3 (AM W20590) all complete, 18 mm long, 1 mm wide, about 90 setigers, 15 mm long, 0.8 mm wide, about 70 setigers, 20 mm long, 1 mm wide, about 90 setigers. All type material from the same lot, Merimbula, seaward side of bridge, NSW, Australia, 36°54'S 149°53'E, Oct. 1976, 2–3 m, *Posidonia australis* seagrass beds. (Remaining material from this lot of 40+ individuals (AM W11347) is thus available for any subsequent SEM examination).

**Additional material.** Australia – South Australia – Upper Spencer Gulf, 33°12'S 138°E, 3 (AM W20593) Aug. 1979, 4.1 m, 795-A4/7, *Posidonia sinuosa* seagrass beds; 2 (AM W20596) 795-B2/2, Aug. 1979, intertidal, *Zostera* spp seagrass beds; 1 (AM W20594) 801-A3/5, March 1980, 3.6 m, *Posidonia australis* seagrass beds; 1 (AM W20595) 795-A4/4, Aug. 1979, 4.1 m, *Posidonia sinuosa* seagrass beds. Victoria – Port Phillip Bay, Hobsons Bay, 37°58'S 144°54'E, few (AM W5645) Stn 1224. New South Wales – Merimbula, 36°54'S 149°53'E, 40+ (AM W11347), 30+ (AM W11427), 30+ (AM W11449) July 1976, 2–3 m, *Posidonia australis* seagrass beds; Jervis Bay, Murrays Basin, 35°08'S 150°45'E, 1 (AM W17529), 4 (AM W17532), 4 (AM W17528) Oct. 1972, 3–4 m, *Posidonia* seagrass beds; Port Hacking, 34°05'S 151°07'E, 10 (AM W195277) 1974, sand; Silver Beach, Kurnell, 34°01'S 151°08'E, several (AM W17697) intertidal; Georges River 34°00'S 151°05'E, 3 (AM W7647) 3 m, mud; Careel Bay, 33°37'S 151°20'E, 1 (AM W8361) 11 Dec. 1973, 1–2 m, *Posidonia australis* seagrass beds; Port Stephens, 32°41'S 152°04'E, 9 (AM W12634), 15 (AM W12622) 27 July 1976, *Posidonia* seagrass beds; Wallis Lake, 32°13'S 152°30'S, 1 (AM W12790) July 1976, 2–3 m, *Posidonia* seagrass beds. A selection of

material examined.

The following material was mounted for examination by SEM, in all cases only part of the registered lot was used: Victoria – Corio Bay, Port Phillip Bay, 38°07'S 144°29'E (AM W unregistered). New South Wales – Merimbula, 36°54'S 149°53'E, 2 (AM W11357); Jervis Bay, Hole in the Wall, Plantation Point 35°08'S 150°45'E, several (AM W unregistered); Towra Point, Botany Bay, 34°01'S 151°08'E, 24 (AM W10842) sand; Weeney Bay, 34°01'S 151°10'E, 4 (AM W12378) 4 June 1977, *Zostera* seagrass beds; Kogarah Bay, 33°59'S 151°07'E, many (AM W7605) 3 m, mud; Silver Beach, Kurnell, 34°01'S 151°08'E, several (AM W17253), intertidal, 25 Feb. 1980; Wallis Lake, 32°13'S 152°30'E, several (AM W unregistered) *Zostera* seagrass beds.

**Description.** Based on type material and material examined by SEM. Body length exceeds 31 mm; length of thorax 3.5 mm; width of thorax to 0.55 mm. Incomplete specimen with 71 segments. Thorax cylindrical or slightly inflated at setiger 2. Abdomen not coiled. Thoracic segments markedly biannulated; setae at mid-segment level on setigers 1–9; in posterior third of segment 10. Abdomen swollen, thinner walled; segments not biannulated, ie, clear demarcation between 10 and 11. Setiger 9 is 0.75 as long as wide; setiger 10 (0.5–0.75) and setiger 11 (0.75). Slight lateral furrow present on thorax. Small nephridiopores between setigers 7 and 8, 8 and 9 and possibly 9 and 10. Robust thorax and anterior abdomen, remaining abdominal segments not as robust and solid. Holotype with midabdominal segments distended with sediment. Colour in alcohol pale yellow. Methyl green staining produces a band of staining over segments 5–9 (Fig. 2g).

Small prostomium with long round-tipped palpode, in holotype obscured by partly everted proboscis. Proboscis finely papillated. Peristomium longer than first setiger. Eyes not apparent.

Setigers 1–4 with 6–12 narrow winged capillary setae in notopodia and 5–8 in neuropodia. Remaining thoracic setigers with 5–8 notopodial hooks and 6–9 neuropodial hooks. No mixed thoracic fascicles present. Thoracic notopodial and neuropodial hooks with distinct neck and shoulder but no constriction present. Hood wide with curved opening (Fig. 8a,b,c). Setal rows uneven so as to appear double in places (Fig. 8d). Hooks with at least 3 rows of teeth above main fang, but typically hood covering hooks; surface of hood textured (Figs 7a, 8c).

Abdominal segments square to rectangular anteriorly, becoming longer posteriorly. Posterior abdominal segments becoming progressively narrower and bell-shaped towards pygidium. Caudal cirrus appears annulated and equal in length to last 7–8 segments. Abdominal hooks with more obvious fang which is long and pointed and slightly beaked. Setiger 10 has hooks like those on more anterior setigers. At mid-abdomen 7 hooks in notopodia and 14 in neuropodia. Abdominal noto- and neuropodial hooks similar with slight constriction, distinct shoulder and short hood, shaft thickened. Hoods flared with margins upturned, strongly textured. Large prominent main fang (Figs 7b, 8e,f).

Structure of abdominal hooded hooks similar throughout abdomen.

Lives in fine mucus tube. Gravid, egg diameter 80  $\mu\text{m}$ .

**Comments.** *Mediomastus australiensis* n.sp. closely resembles *M. californiensis*, with which it has been confused in the past, but it can be clearly distinguished by the shape and structure of the hooded hooks. In *M. californiensis* the hood is elongated and there are numerous accessory teeth above the main fang, whereas in *M. australiensis* the hood is short and there are few teeth above the main fang. *Mediomastus australiensis* can also be distinguished from the other species of *Mediomastus* using the characters shown in Tables 1 and 2.

It appears that along the east coast of Australia there is a southern species of *Mediomastus*, *M. australiensis* and a more northerly species *M. calliopensis* (Fig. 12). *Mediomastus californiensis* Hartman does not occur in Australia.

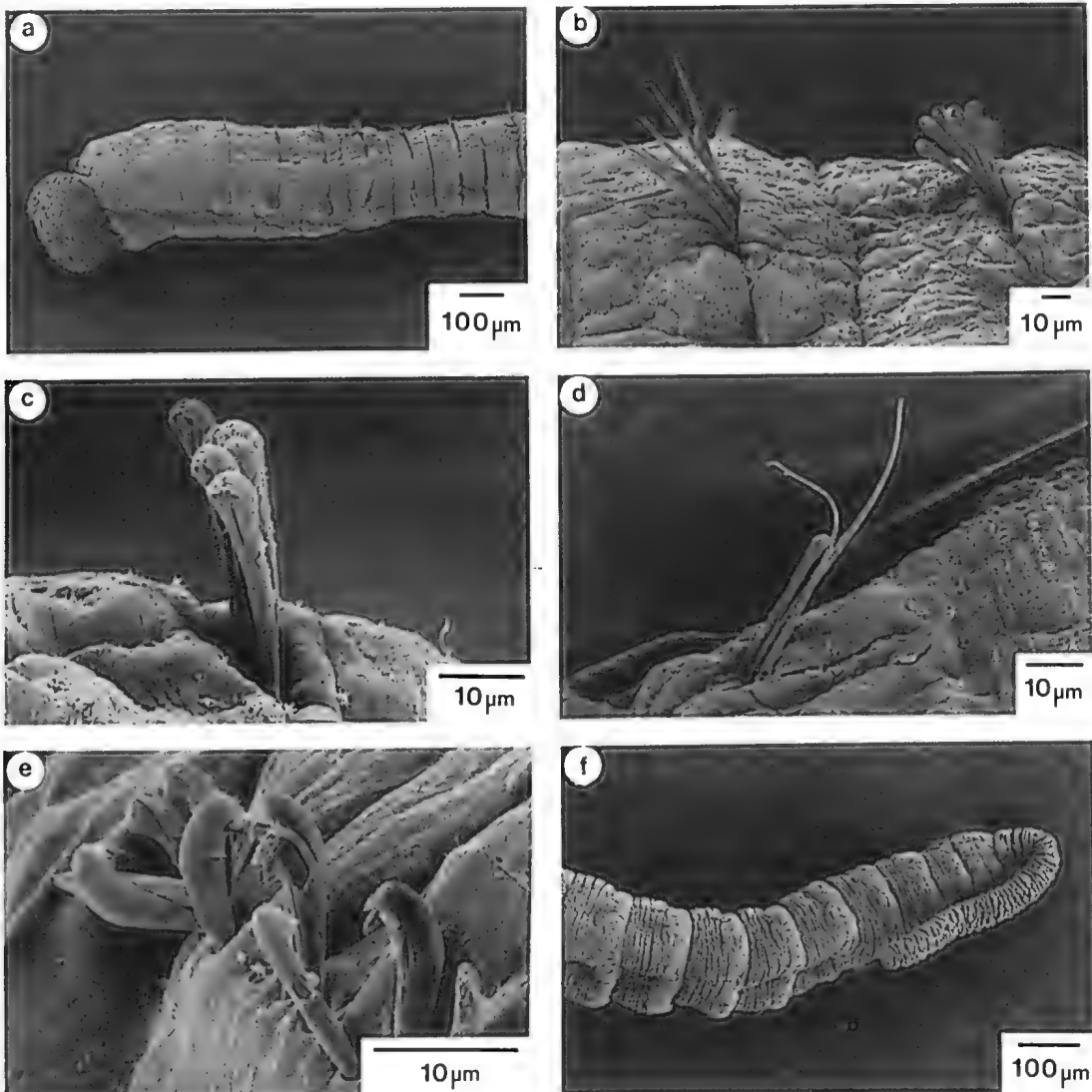
To date only a few specimens of *Mediomastus* have been collected from the Perth region. This Western Australia material was incomplete and too dirty to examine under the SEM. So at this stage it is not known whether *M. australiensis* extends westward of Upper Spencer Gulf in South Australia.

Some of the type material which was collected in October 1976 was gravid, with the coelomic oocytes concentrated in the posterior segments.

**Etymology.** The specific name refers to the geographical region in which this species occurs.

**Habitat.** Often occurs in sheltered bay and estuarine situations where salinity levels are high, in muddy substrates and often is associated with species of *Posidonia* and *Zostera* seagrasses. The species can occur in extremely high densities.

**Distribution.** East coast of Australia from Wallis Lake, NSW to Upper Spencer Gulf, SA (Fig. 12).



**Fig. 6.** *Mediomastus ambiseta*: a – prostomium with partially everted proboscis and anterior thoracic segments; b – thoracic setiger 4 (left) and setiger 5 (right) showing transition from capillary setae to hooded hooks; c – thoracic setiger 6; d – Posterior abdominal notosetae; e – posterior abdominal neurosetae; f – posterior segments with caudal cirrus.

*Mediomastus branchiferus* Hartmann-Schröder

Fig. 12; Tables 1, 2

*Mediomastus branchiferus* Hartmann-Schröder, 1962: 142-143, pls 17-19.

**Type material examined.** HOLOTYPE (HZM P-19158), Callao between Punta and El Camotal, Peru, 34°56'S 72°14'W, Stn C2 11 20, coll. Noodt, 29 May 1956, consists of 3 fragments which may constitute an entire specimen; anterior thoracic fragment 1 mm long, 0.5 mm wide, middle fragment 1 mm long, posterior fragment 1.5 mm long; total number of setigers present 35.

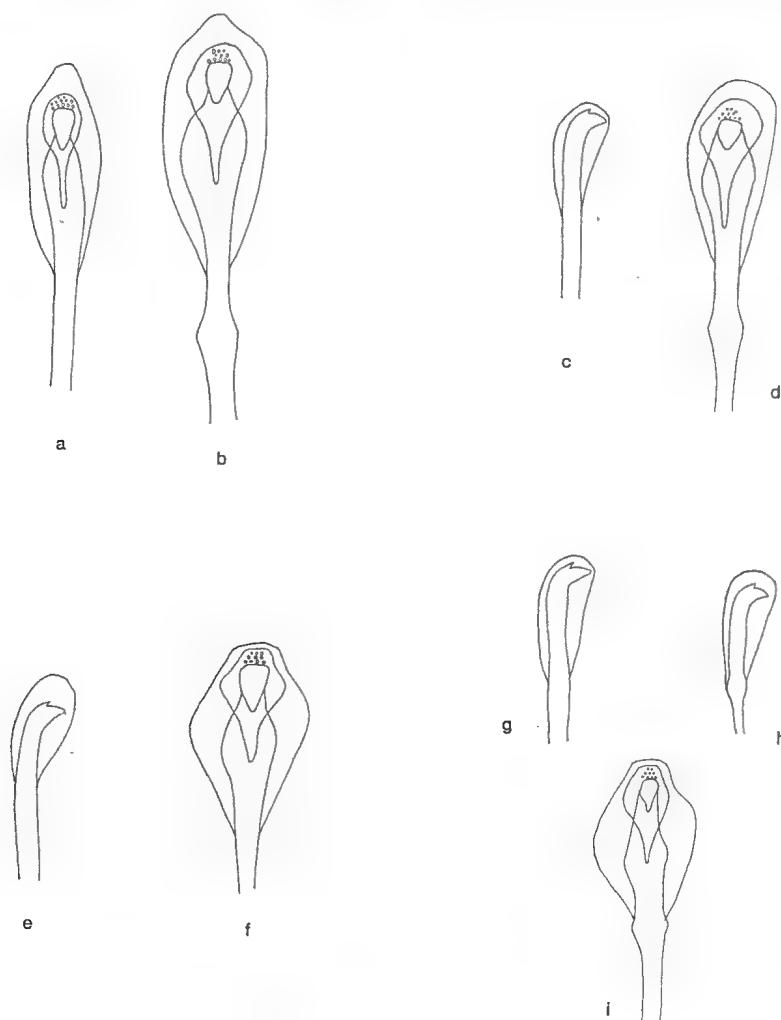
**Additional material.** Chile – Punta Iloca, 34°56'S 72°14'W, 3 (HZM P-15097) incomplete specimens, 12 mm long, for 44 setigers, gravid, 8 mm long for 47 setigers, gravid, 4 mm long for 24 setigers, not gravid.

**Description.** Type material is in poor condition,

holotype consists of 3 fragments, and paratypes examined consist of 3 incomplete specimens. Prostomium with small rounded palpode, eye spots not seen. Proboscis not everted. Asetigerous peristomium.

Thoracic setigers 1-4 with 2-5 winged capillary setae per fascicle. Thoracic setigers 5-8 with 2-3 hooded hooks; a single row of 2 teeth above the main fang; with no constriction in shaft; long narrow hooded hooks, hoods 3 times as long as wide. Junction between thorax and abdomen very damaged. Nephridiopores not visible. Abdomen with hooded hooks, with 1-3 per fascicle in anterior abdominal notopodia; neuropodia with 6-8 per fascicle. Posterior fragment of holotype with 18 setigers, notopodia with single notosetae plus 1 or 2 hooded hooks, very small and deeply embedded in epidermis, shaft difficult to see, but no obvious constriction, long narrow hood.

**Comments.** Hartmann-Schröder (1962) originally described an intact worm. The holotype is now in three



**Fig. 7.** Schematic figures of setae. *Mediomastus australiensis*: a – thoracic hooded hook, head on view; b – abdominal hooded hook, head on view. *Mediomastus californiensis*: c – thoracic hooded hook, lateral view; d – abdominal hooded hook, head on view. *Mediomastus calliopensis*: e – thoracic hooded hook, lateral view; f – abdominal hooded hook, head on view. *Mediomastus fragilis*: g – thoracic hooded hook, lateral view; h,i – abdominal hooded hook, lateral and head on views.

fragments, and it is not possible to confirm the presence or absence of the transitional zone between the thorax and the abdomen. Eyes are not visible on the type material although they are mentioned in the original description.

Because of the damaged nature of the abdominal segments we cannot confirm the presence of two or more long papillae or thread-like processes on the short posterior abdominal segments situated dorsally above the notopodia which Hartmann-Schröder describes as branchiae. The presence of branchiae would enable this species to be easily distinguished from all other described species of *Mediomastus*. Until additional complete material from the type locality can be collected and described, we have referred to the species as a *species inquirenda*.

However, we have included the species in Tables 1 and 2.

**Habitat.** Collected from the holdfasts of *Macrocystis*.

**Distribution.** Known only from the type localities in Peru and Chile (Fig. 12).

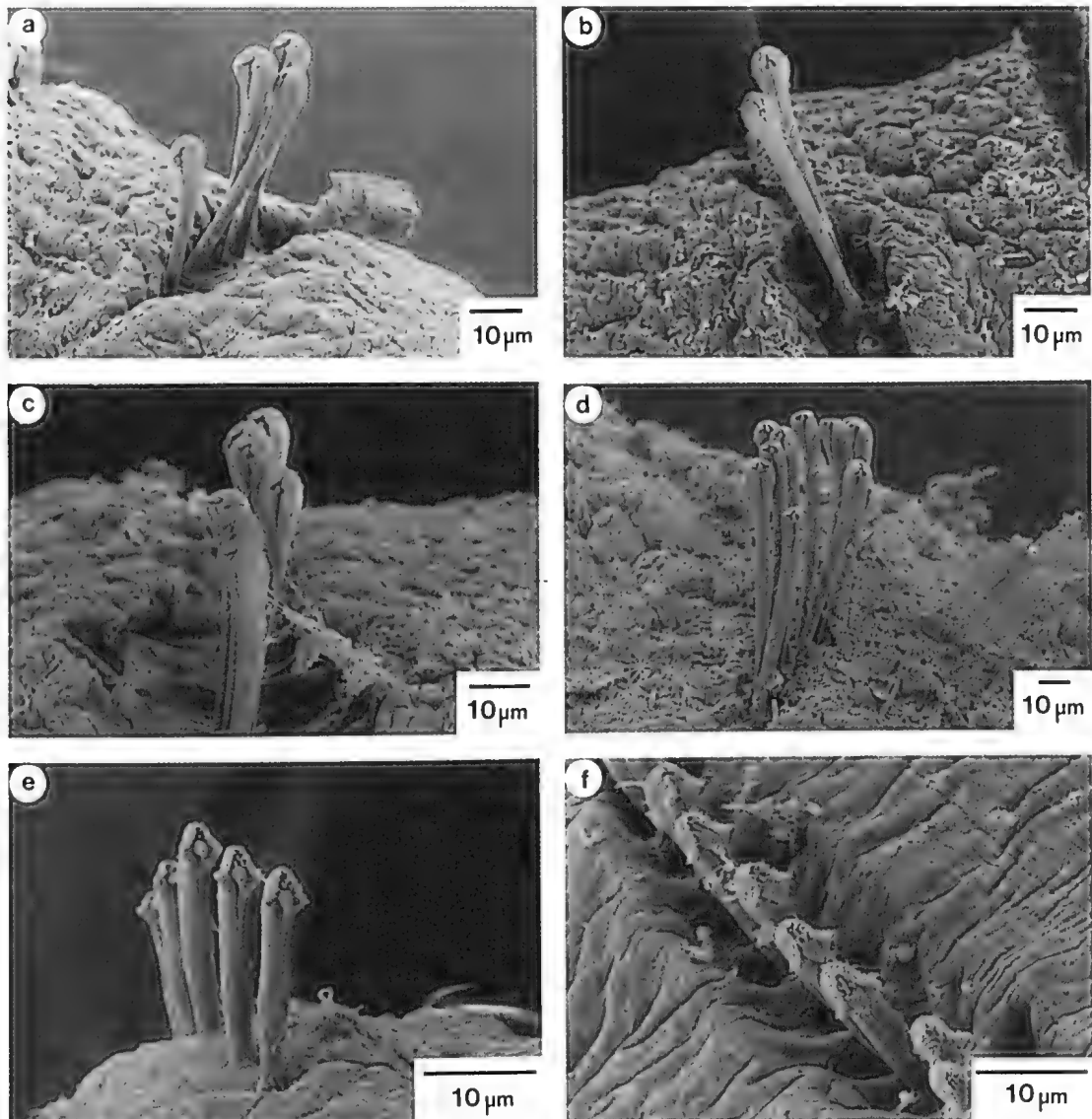
### *Mediomastus californiensis* Hartman

Figs 2b, 7c–d, 9a–d, 12; Tables 1, 2

*Mediomastus californiensis* Hartman, 1944: 264–265, pl. 26, figs 64, 65.—Hartman, 1947: 408, pl. 46, figs 3–4.—Hartman, 1969: 387–388, figs 1–4.—Ewing, 1984 (Ch.14): 14–16, figs 14–9, 14–10a–c.

*Mediomastus capensis*.—Fournier & Levings, 1982: 36 (not Day, 1961).

**Type material examined.** HOLOTYPE (LACM-AHF 63 (n 747) Poly 0428) Tomales Bay, California, USA, 28°25'N 123°W, 8 June 1941, intertidal, 1 individual in 2 fragments, anterior fragment 13 mm long, 0.5 mm wide anterior thorax, 0.3 mm wide posterior thorax, for 34 setigers, posterior



**Fig. 8.** *Mediomastus australiensis* n.sp.: a – thoracic neurosetae setiger 5; b – thoracic notosetae setiger 6; c – thoracic neurosetae setiger 6; d – thoracic notosetae setiger 5; e – notosetae setiger 23; f – neurosetae setiger 14.



fragment 20 mm in long, 0.5 mm wide tapering gradually, extreme posterior setigers 0.2 mm wide, 83 setigers, caudal cirrus missing.

**Additional material.** USA – California – (LACM-AHF n 1488), several mounted for SEM examination; San Diego Bay, 32°45'N 117°10'W, 5 (LACM-AHF) to 20 m Stn F2 + N2; Florida – Hutchinson's Island, St Incie Co., 27°22'08"N 80°13'46"W, several (AM W12047) 10.3 m; North Carolina – off Beaufort 34°34'N 76°25'W, several (AM W12046) 20 m. Canada – British Columbia – (as *M. capensis*) Cousins Inlet 52°17.2'N 127°45.8'W, 4 (AM W18393) 90 m, silt, gravel; Cousins Inlet 52°18.1'N 127°45.3'W, 5 (AM W18394) 70 m, silt, gravel; Graham Reach, Swanson Bay 53°08'N 128° 30.5'W, 7 (AM W18385) 51 m, sand; Graham Reach, Swanson Bay, 53°0.6'N 128°30.6'W, 3 (AM W18396) 66 m, wood debris under 2-3 cm sand.

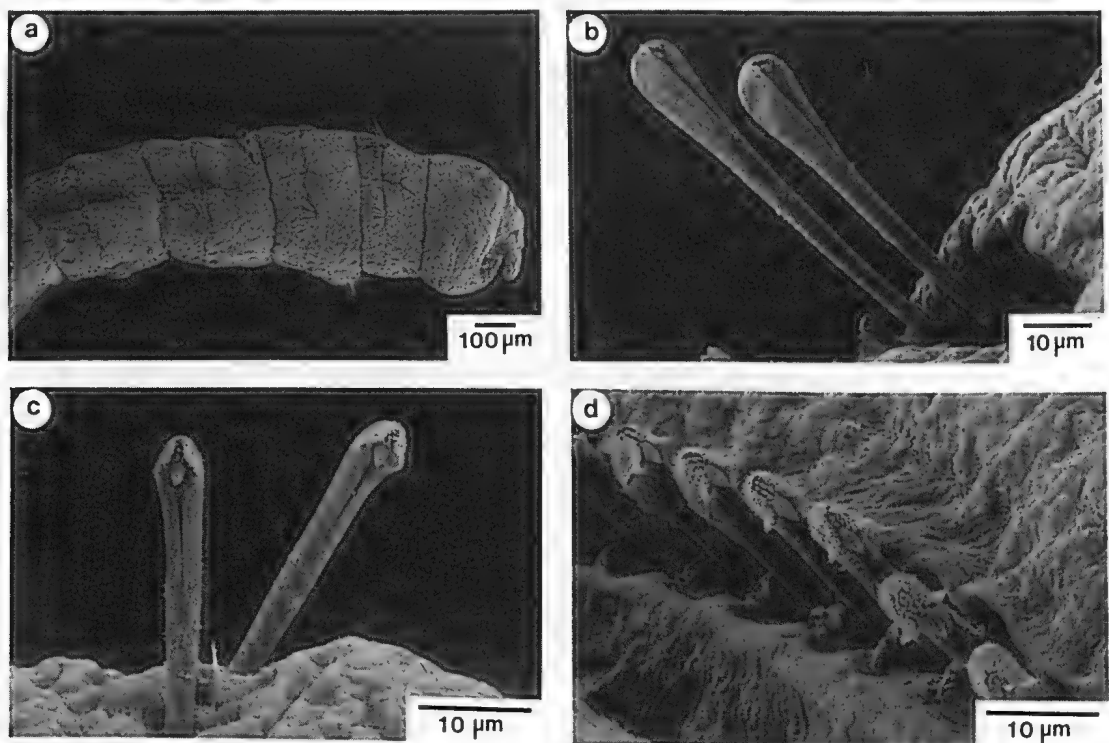
**Description.** As type material is incomplete the following description is a composite one based on all the material examined including some examined under the SEM. All the material examined had been collected and identified by Hartman. Body length to 35 mm; length of thorax to 3 mm; width of thorax to 0.5 mm. Number of segments may exceed 100. Worm solid and muscular; widest at second and third setigers (Fig. 9a); tapers slightly to end of body. Abdomen loosely coiled. Thorax/abdomen boundary readily recognisable by sudden constriction caused by change in size and shape of segments. In the holotype first abdominal segment inflated posteriorly, narrowed anteriorly; in all other material last thoracic setiger posteriorly narrowed. Pale yellow or colourless in alcohol; abdomen not usually transparent. Staining

with methyl green produces a distinct band on setigers 7, 8 and especially posterior part of 9, and faint bands on setigers 5 and 6, setiger 10 unstained (see Fig. 2b).

Small prostomium with more or less elongated, round-tipped palpode. Eversible proboscis with widely scattered low papillae that may appear prominent or be inconspicuous. Peristomium as long or longer than wide; longer than anterior setigers. Two small eye spots mid-dorsally in anterior peristomium; not always apparent.

Thorax of 10 setigers; setigers 1-4 about 0.5-1 times as long as wide (Fig. 9a); setiger 5 shorter, about 0.5 times as long as wide; setiger 6-10 gradually increasing in length to 0.75-1 times as long as wide. Setigers 2 and 3 slightly wider than other thoracic setigers. Thoracic setigers biannulated, markedly so from setiger 5. Holotype with deep midlateral groove on all thoracic setigers.

Nephridiopores between setigers 7 and 8, 8 and 9 and possibly 6 and 7, and 9 and 10; not always apparent. Setigers 1-4 with narrow, smooth winged capillary setae only; setigers 5-10 with hooded hooks only. Fascicles of setigers 1-7 inserted posterior to mid-segment; those on setigers 8-10 progressively more posterior. Number of setae per fascicle variable within and between individuals; capillary setae range from 5-15 per fascicle in notopodia, 5-11 in neuropodia; thoracic hooks range from 4-8 in notopodia, 5-10 in neuropodia. Thoracic hooks long and prominent; long shaft with no obvious shoulder, tapering slightly distally; no proximal constriction; small fang surmounted by several rows of teeth; 2 or more large



**Fig. 9.** *Mediomastus californiensis*: a – prostomium and anterior thoracic segments; b – thoracic hooded hooks on setiger 5; c – hooded hooks on setiger 14; d – hooded hooks on setiger 38.

teeth in basal row. Hood long, gently tapering into shaft. Length 3 times width (Fig. 9b). Number of abdominal segments not fixed; may exceed 100. Anterior segments slightly wider than posterior thoracic segments; about 1-1.5 times as long as wide; increasing in length in mid-abdomen, decreasing posteriorly to 0.75 times width. Abdominal segments multi-annulated with posterior parapodial ridge; posterior abdominal segments slightly wider posteriorly; bell-shaped. Branchiae absent. Pygidium with midventral caudal cirrus.

Abdominal setigers with hooded hooks only. Anterior setigers with 5-7 hooks per fascicle in notopodia and 8-10 in neuropodia; midabdominal setigers with 4-5 hooks in notopodia, 8-12 in neuropodia; posterior setigers with 2 hooks in notopodia, 4 in neuropodia. Abdominal hooks similar to thoracic hooks, with slight shoulder; slight constriction; not always clear. The arrangement of teeth above the main fang, as viewed under oil immersion, varies within a torus. Majority of hooks with squat triangular cap of teeth; at least 3 rows of about 12 irregularly arranged teeth. At least 3 teeth in basal row. Single hook in each fascicle with slightly enlarged teeth in basal row. Hood slightly shorter than in thoracic hooks (Fig. 7c,d).

Gravid female with large number of small eggs in the coelom; egg diameter about 60  $\mu$ m.

**Comments.** The holotype is incomplete posteriorly and in two fragments, an anterior end with 34 setigers, 13 mm long and an abdominal fragment of 83 setigers, 20 mm long. Complete specimens fitting the description have been recorded extensively from North America.

*Mediomastus californiensis* may easily be distinguished from *M. ambiseta*, whose distribution it overlaps, by its much more muscular, solid appearance, even if the lack of a posterior end prevents comparison of notopodial setigers. It is also unlike other species in that the structure of thoracic and abdominal hooks is similar. Fournier & Levings (1982) identified Canadian specimens of this species as *M. capensis* (material examined by us) but they may be distinguished by the distinctive setal morphology of *M. capensis* (see below). See Table 1 for other features which distinguish *M. californiensis* from other species of *Mediomastus*.

**Habitat.** *Mediomastus californiensis* occurs in sandy mud flats at low water, sometimes associated with the capitellid *Notomastus tenuis* (Hartman, 1944). Hartman (1963) also records the species from depths of 517 m off southern California but we doubt the authenticity of this record.

**Distribution.** North America from both the west and east coast (Fig. 12) and the Gulf of Mexico (Ewing, 1984). However, we have not examined Ewing's material and therefore have not substantiated the species presence in the Gulf of Mexico.

### *Mediomastus calliopensis* n.sp.

Figs 2e, 7e-f, 10a-f, 12; Tables 1, 2

*Mediomastus californiensis*.—Saenger *et al.*, 1980: 160 (not Hartman, 1944).

*Mediomastus* sp. Saenger *et al.*, 1980: 159.—Moverley *et al.*, 1986: 227-321.

**Type material examined.** HOLOTYPE (AM W20591) complete, 14 mm long, 1.0 mm wide anteriorly and 0.4 mm posteriorly, about 90 segments, PARATYPES 2 (BMNH ZB 1994.4795-4796) both complete, 10 mm long, 0.5 mm wide anteriorly, 0.2 mm posteriorly, about 51 segments, 8 mm long, 0.6 mm wide anteriorly, 0.3 mm posteriorly, about 60 segments; 2 (USNM 136598) both complete, 12 mm long, 1.0 mm wide anteriorly, 0.3 mm posteriorly, about 75 segments, 20 mm long, 1.2 mm wide anteriorly, 0.4 mm posteriorly, about 85 setigers, 2 (LACM-AHF 1649) both complete, 12 mm long, 1.0 mm wide anteriorly, 0.3 mm posteriorly, about 69 segments, 8 mm long, 1.0 mm wide anteriorly, 0.3 mm posteriorly, about 60 segments, 14 (AM W 20592) all complete; all type material from Calliope River, Gladstone, Queensland, Australia, 24°01'S 150°59'E, collected between 1974 and 1983, 7-8 m, 3.8 km upstream, sandy mud.

**Additional material.** From same batch as type material, many (AM W 199325), some of this material is gravid, and some has been mounted for SEM examination.

**Description.** Small fragile worm strongly tapering towards posterior end. Body length to 27 mm, length of thorax to 2.6 mm, width of thorax to 0.3 mm. Up to about 100 segments. Thread-like, thorax cylindrical, solid, segmental grooves not indented whereas in abdomen clear segmental demarcation present caused by intersegmental grooves. Abdomen not coiled. Clear demarcation between thorax and abdomen between setigers 10 and 11. Colourless in alcohol with transparent abdomen. Methyl green staining produced stippled staining on segment 9 and weak staining on segments 8 and 10 (Fig. 2e).

Small prostomium with elongate palpode with rounded tip. Eversible proboscis with low papillation. Peristomium longer than thoracic segments. Eyes not apparent. Nephridiopores not seen.

Thorax of 10 setigers increasing in length from setiger 5 from 0.33 times width to 1-1.5 times width at setiger 10. Clear demarcation between setigers 10 and 11, first 10 setigers more muscular than subsequent segments. In some type material distinct lateral groove extending from setiger 1 to end of setiger 10, posteriorly body wall unconstricted. Anterior abdominal segments rectangular and clearly demarcated segmentally but posterior abdominal segments bell-shaped and extreme posterior segments narrow and extremely compressed. Alimentary canal clearly visible through posterior abdominal walls and body walls appear thinly muscularised. Marked colour change from cream on first 10 setigers to darker brown on posterior setigers, ventral glandular stripe present pale cream. Setigers 1-4 with narrow, smooth, winged capillary setae only (Fig. 10a), 5-14 per bundle;



setigers 5-10 with hooded hooks only. Number of hooks per torus range from 4-13. No differences in setal numbers between thoracic noto- and neuropodia.

Setal fascicles situated at mid-segment level except for those on setiger 10 where positioned posteriorly on segment.

Thoracic hooks with stout, short straight shaft, head small, hood wide with wide opening (Figs 7e, 10b-c).

Anterior abdominal setigers same size as posterior thoracic setigers but thereafter length increases greatly to 4 times width but is variable within type material. Towards posterior end, segments relatively shorter with parapodial ridges.

Abdominal setigers with hooded hooks only, numbering 12-13 per bundle anteriorly, 16-17 in mid-abdomen, 5-8 posteriorly in neuropodia and about 5 per bundle in notopodia. Hooks may be absent from last few segments, possibly as a result of regeneration.

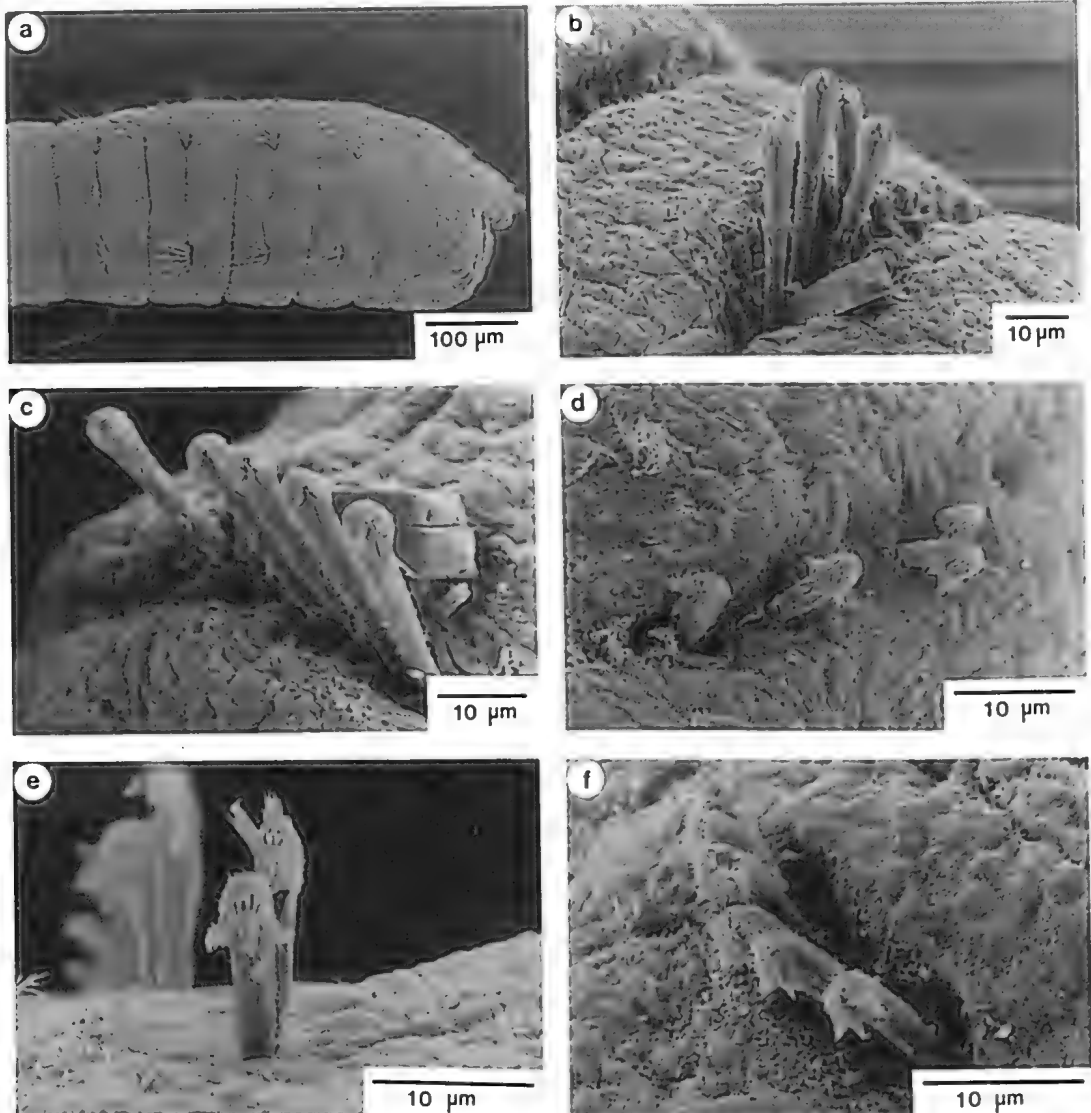
Abdominal hooks shorter than thoracic hooks with curved, prominent shoulder and long fang (Figs 7f,

10d-f). Hood only 1-2 times as long as wide and much shorter than in thorax. Caudal cirrus narrow, thin, length of last 5-7 segments.

Type material includes 2 specimens with sperm morulae in coelom, and non-type material includes coelomic oocytes 50-57  $\mu\text{m}$  in diameter.

**Comments.** *Mediomastus calliopensis* can be easily distinguished from *M. australiensis* by the structure of the hooded hooks and the general body form. *Mediomastus calliopensis* is a small fragile worm in contrast to the robust *M. australiensis*. The thoracic hooded hooks have longer hoods than those found in *M. australiensis*, and the abdominal hooded hooks in *M. calliopensis* have more flared bases than those present in *M. australiensis*. For further distinguishing characters and how it can be separated from other described species of *Mediomastus* see Tables 1 and 2.

The species currently has a restricted geographical range, but it should be stressed that few if any shallow



**Fig. 10.** *Mediomastus calliopensis* n.sp.: a – prostomium and anterior thoracic segments; b – thoracic neurosetae setiger 7; c – thoracic notosetae setiger 10; d – notosetae setiger 23; e – notosetae setiger 27; f – neurosetae setiger 38.

coastal polychaete collections have been made in Queensland or estuarine tropical Australia (Fig. 12).

All the material was collected during an environmental survey of Calliope River carried out by Saenger *et al.*, during the years of 1974 to 1983, and the species was restricted to Sites 19 and 22 (for site details see Saenger *et al.* (1980)). However all the material which was deposited in the AM had been pooled so that details of actual dates of collection are unknown. Some material was sexually mature but it is not known when this was collected. Sexually mature material was not larger than non sexually mature material.

**Etymology.** The specific name is derived from the type locality, the Calliope River.

**Habitat.** Estuarine in muddy sediments, salinity range from 6.53 p.p.t. to 37.94 p.p.t.

**Distribution.** Known only from Calliope River, central Queensland (Fig. 12).

### *Mediomastus capensis* Day

Figs 2c, 12; Tables 1, 2

*Mediomastus capensis* Day, 1961: 518-519, fig. 11a-d.—Day, 1967: 600-601, fig. 28.2n-p.—Hartmann-Schröder, 1974: 187. not *M. capensis*.—Thomassin, 1970: 80, fig. 5a-d. not *M. cf. capensis*.—Gibbs, 1971: 186. not *M. capensis*.—Fournier & Levings, 1982: 36-37.

**Type material examined.** HOLOTYPE (SAM A-20587) Cape SB 211F, Univ. Cape Town Ecol. Survey, South Africa, 33°03'S 18°01'E, 1 May 1960, incomplete posteriorly, 14 mm long, 0.9 mm wide, gravid; PARATYPES (BMNH 1961.9 558-604) St WCD 61J, 63N, 68R, 70H, 82G grab, Univ. Cape Town Ecol. Survey, South Africa, 32°05'-32°44'S 17°56'-18°06'E, 21 Sept. 1960, 95 m, 11, all posteriorly incomplete; 4 (SAM A-20588) anterior fragments plus an abdominal fragment, 4 mm long, thorax plus 15 abdominal segments, 5 mm, thorax plus 16 abdominal segments, 3 mm long, thorax plus 12 abdominal segments, 3 mm long, thorax plus 7 abdominal segments, gravid; 2 (SAM A-20589) 1 complete with regenerating posterior end, 10 mm long, 0.9 mm wide, about 44 segments, incomplete, 7.5 mm long, 0.8 mm wide, about 28 setigers.

**Additional material.** Mozambique — Lourenço Marques 25°48'S 32°51'E, (HZM P-15100).

*Mediomastus* sp. cf. *capensis* Solomon Islands, Marovo lagoon, New Georgia, 8°50'S 158°20'E (BMNH:1970-711), 18 m, mud.

**Description.** Body length 14 mm for 60 setigers; length of thorax to 4 mm; width of thorax to 0.9 mm. Thorax widest at setigers 2-3 narrowing anteriorly; narrower but cylindrical posteriorly. Abdomen loosely coiled. Thorax/abdomen boundary apparently clearly marked by change in width and shape of segments

after setiger 10. Setiger 10 is transitional, however, in that its size and shape is like anterior setigers but the position of the setae is like that found on abdominal setigers. Pale brown in alcohol; thorax not transparent, abdomen slightly transparent. In methyl green, a distinct band around posterior half of setiger 9 (Fig. 2c).

Prostomium with small round-tipped elongated palpode. Eversible proboscis with indistinct papillae; may appear smooth. Peristomium about same length as first setiger. Eyes may or may not be apparent.

Thorax of 10 setigers; posterior segments slightly longer, about as long as wide. Setigers 1-3 show a gradual increase in width to maximum at setiger 3 which is about two-thirds as long as wide; setiger 4 gradually narrows; setigers 5-10 are all similar in width. Segments biannulated, markedly so from setiger 5; epidermis otherwise smooth or crenulated. Nephridiopores between setiger 8 and 9; 9 and 10; may not be apparent. Setigers 1-4 with winged capillary setae, curved into minute hooks at tip. Setigers 5-10 with hooded hooks only. Setae in 4 equally spaced fascicles, inserted midsegmentally on setigers 1-9; more posteriorly on setiger 10. Number of capillary setae per fascicle ranges from 6-13 in notopodia; 6-12 in neuropodia. Number of hooded hooks ranges from 5-11 in notopodia; 3-10 in neuropodia. Thoracic hooks very prominent with long straight shaft without shoulder. Small fang surmounted by at least 3 irregular, steeply banked rows of teeth with 5-8 in first row. Voluminous hood, tapering into shaft, length about 2-3 times width.

Anterior abdominal segments slightly shorter than posterior thoracic segments, length about 0.75 times width; length increasing to 1.5 times width posteriorly. Segments thin walled with prominent ventral gutter. Posterior margin of segments with parapodial ridge. Branchiae absent. Abdominal setigers with hooded hooks only, 5 per fascicle in notopodia and 11 in neuropodia. Hook not very different from thoracic hook; slightly shorter with slight shoulder, more obvious in more posterior segments; no constriction. Main fang only slightly larger than in thoracic hooks, surmounted by at least 2 steeply banked rows of teeth, first row with 2 or 3 large teeth. Hood shorter than in thoracic hook, length about 2 times width.

Holotype is gravid with large number of immature small eggs. Diameter of eggs floating freely in coelom is 40  $\mu$ m.

**Comments.** The type material is described by Day (1961) as "fairly complete", but he also gives details of the posterior with a caudal cirrus, although he does not describe the posterior setae. We have only examined one paratype which was complete but this specimen was regenerating and posterior setae were not visible; the holotype is now in two pieces and incomplete posteriorly. The type locality is given in Day (1961) as Stn SB 232 Saldanha Bay 33°04'S 18°00'E, depth 8-12 m, bottom

khaki sand but the holotype and paratypes are labelled Stn SB 211F and Stn WCD 61J, 63N, 68R, 70H, 82G with slightly different latitudes and longitudes. In the published description, Stn SB 211F is listed as having one juvenile only. The number of paratypes (12+3 posterior ends) examined is greater than listed by Day (1961) for the paratype material (8). Day (1961) indicates that the types would be deposited in the South African Museum but no material could be located; instead the holotype was found in the Zoology Department, University of Cape Town, together with some paratypes and additional paratypes were located in the BMNH. The types located in the Zoology Department have now been deposited in the South African Museum. However all the type material examined was collected from within the same geographical area and are the same species. The discrepancies between the labels and the published description appear to be topographical.

In Day's original description (1961) the dental formula of the hooded hooks is given as MF:5-6:3-4 but in Day (1967) the dental formulae is given as MF:8:3-4. We observed at least three irregular rows of teeth present above the main fang. *Mediomastus capensis* may be distinguished from other species by its hooked capillary setae and by its hooded hooks, which do not differ markedly between those present in the thorax and abdomen. They are very prominent, with voluminous hoods, small fangs and a crest of teeth which gives them an almost bifid appearance at the tip. It must be emphasised, however, that the abdominal hooks on more posterior segments might not conform to this pattern, as no posterior fragments were available for examination.

For comparisons of *M. capensis* with other species of *Mediomastus* see Tables 1 and 2.

*Mediomastus capensis* has also been recorded from the Mediterranean (Italy, Spain, France – see, for example, Giangrande & Gambi, 1986, Campoy, 1979, Willsie, 1986) but this material has not been examined. Material from British Columbia (Fournier & Levings, 1982) is indistinguishable from *M. californiensis* Hartman. The only records which have we have substantiated as *M. capensis* are those from Mozambique (Hartmann-Schröder, 1974).

Gibbs (1971) recorded *Mediomastus* sp. cf. *capensis* from the Solomon Islands but it is an incomplete specimen, and cannot be identified with any certainty to species. However it seems unlikely from the known distribution of *M. capensis* that this anterior fragment is in fact *M. capensis*.

Thomassin (1970) recorded *M. capensis* from Madagascar. Re-examination of this material has shown it to be a new species *M. thomassini* which we describe in this paper.

**Habitat.** *Mediomastus capensis* is recorded as occurring in sand at shallow depths (Day, 1961).

**Distribution.** South Africa and Mozambique (Fig. 12).

## *Mediomastus cirripes* Ben-Eliahu

Figs 2f, 12; Tables 1, 2

*Mediomastus cirripes* Ben-Eliahu, 1976: 138, fig. 6a-c.

**Type material examined.** HOLOTYPE (BMNH. ZB.1976. 161) Shavei Zion, Israel, 32°59'N 35°05'E, 347.2 km north of Bet Ha'Emek creek, 8 May 1971, *Dendropoma* infauna, incomplete, 3.3 mm long.

**Description.** Holotype consists of an anterior end with a complete thorax and 6 abdominal setigers. The thorax is 1.6 mm long, 0.4 mm wide at widest point (setiger 3). The boundary between thorax and abdomen marked by a deep intersegmental groove between setigers 10 and 11 but setiger 10 shows some features typical of abdominal setigers. Colourless in alcohol and transparent. Methyl green staining (Fig. 2f) produced a solid band of colour extending from setiger 6 to the midsegmental groove on setiger 9 with the heaviest staining on setiger 9. This intense stain extended posteriorly on the dorsal surface of the rest of setiger 9. The remainder of setiger 9 and setiger 10 less intensively stained; with darkly stained dots in addition. Abdominal setigers with a narrow band of colour at the extreme posterior end.

Prostomium small, conical with prominent, elongated round-tipped palpode. Eversible proboscis with low, poorly defined papillae. Peristomium 1.5 times longer than first setiger. Two red eye spots, dorsally on peristomium.

Thorax of 10 setigers of which the tenth is transitional. Setigers 1-9 about 0.5 times as long as wide; setiger 10 slightly longer. Setigers clearly biannulated; additional annulations on setiger 10. Nephridiopores not visible. Setigers 1-4 with broad-winged, pointed capillary setae which may be stiff or flexible; those on setiger 1 less prominent than the rest. Numbers of capillary setae range from 2-5 in notopodia and 2-4 in neuropodia. Setigers 5-10 with hooded hooks only, numbering 2-5 in notopodia and 2-4 in neuropodia. Setae in 4 equally spaced fascicles placed slightly posterior to mid-segment level in setigers 1-9, further back on setiger 10.

Thoracic hooks with long, straight shaft with no shoulder and no constriction, surmounted by a small fang with at least 3 rows of small teeth; hood wide, about 2-3 times as long as wide.

Anterior abdominal setigers slightly longer than setiger 10; up to about as long as wide; multi-annulated; setae situated near posterior margin of setiger; 4-5 setae per fascicle. Abdominal setigers with hooded hooks only, not very different from those on thorax but shaft slightly shorter with a slight shoulder and slight constriction. Fang slightly longer and more pointed than in thoracic hooks. Hood wide, but not as wide as in thorax; shorter than in thorax.

The holotype is a gravid female with eggs still attached in gonad; egg diameter approximately 65  $\mu$ m but not fully rounded.

**Comments.** The original description refers to a rounded pygidium, without a caudal cirrus. It appears, however, that the worm had lost its posterior end some time prior to collection. The holotype differs from specimens of other species of *Mediomastus* by the morphology of the hooks on thorax and abdomen; the shape of the setigers including the thorax/abdomen boundary; and the prominent palpode. With the possible exception of the hook morphology, however, these characters may well be variable within the species and without further material it is impossible to speculate on the likely range. Furthermore, the specimen lacks most of its abdominal setigers which might contain other diagnostic features. The locality and the habitat, however, suggest that this might be a separate species. Nevertheless, because we have been unable to give a complete description we prefer to refer to *M. cirripes* as a *species inquirenda*. However we have included this species in Tables 1 and 2, and have listed the known characteristics of the species and how it compares with other species. Collection of additional material from the type locality may substantiate this species.

**Habitat.** Associated with vermetid reefs of *Dendropoma*.

**Distribution.** Known only from the type locality on the Israeli coast in the Mediterranean (Fig. 12).

### *Mediomastus deductus* (Pillai)

Fig. 12; Tables 1, 2

*Heteromastus deductus* Pillai, 1961: 29-30, figs 9j-k, 10b-c.

**Type material examined.** HOLOTYPE (BMNH 1960.3.13.24) Tambalagam Bay, Sri Lanka, 8°28'N 81°07'E, oyster beds, brackish water in centre of lake, Nov. 1959, 1 incomplete anterior end, 12 mm long and 1 abdominal fragment, 25 mm long.

**Description.** The anterior end consists of a thorax with 15 abdominal segments; total length of about 12 mm (abdomen highly coiled and, therefore, difficult to measure accurately); length of thorax 4 mm; width 0.8 mm. Abdominal fragment of 47 segments; about 25 mm long; incomplete posteriorly. Thorax/abdomen boundary very indistinct; abdominal segments more wrinkled and with parapodial ridge. Setiger 10 is typical of thoracic setigers in shape and hook morphology. Methyl green staining did not produce any staining patterns.

Small, conical prostomium with long round-tipped palpode. Eversible proboscis with very distinct low papillae. Peristomium as long as first setiger; no eye spots.

Thorax of 10 setigers. Setigers 1-6, 0.5 times as long as wide; biannulated. Setigers 7-10 longer, length 1.25-1.75 width. Thorax cylindrical; all segments the same width. Nephridiopores not visible. Setigers 1-4 with

narrow winged capillary setae; some with hooked tip. Setigers 6-10 with hooded hooks only. Setiger 5 badly damaged; 3 of the parapodia appear to have been cut out, no setae visible on remaining thoracic setigers. Setae in 4 equally spaced fascicles at mid-segment level in setigers 1-6, gradually further back on setiger in remaining thoracic segments. Capillary setae and hooks range in number from 2-4 per fascicle.

Thoracic hooks not very prominent; shaft straight without shoulder or constriction; small fang with a low lying crown of small teeth in at least one row; hood very long and wide, length about 4 times width.

Anterior abdominal segments same length as posterior thoracic segments; multi-annulated and wrinkled in appearance; posterior segments longer. Distinct parapodial ridge from first abdominal setiger; much less obvious in the abdominal fragment. Setae positioned near posterior end of setiger. Abdominal segments with hooded hooks only; 1-2 on anterior segments increasing to 4 on more posterior segments.

Abdominal hooks very short and difficult to detect; distinctive shoulder; constriction not apparent; stout, prominent fang with a very indistinct row of small teeth; hood tightly fitting with fang protruding through opening.

Both fragments contained mature eggs floating freely in the coelom; egg diameter 65  $\mu$ m.

**Comments.** The original description refers to an incomplete worm, 34 mm long for 80 segments. Both the description and the figure show setiger 5 with hooded hooks and no capillary setae. Although *M. deductus* is known only from two fragments, they exhibit sufficient characters to characterise the species. *Mediomastus deductus* may be distinguished from all other species of *Mediomastus* by its very short abdominal hooks. Although we cannot confirm the thoracic setal formula and the possibility therefore remains that this is a species of *Heteromastus*, the original description is very clear in its reference to the fifth setiger having hooded hooks only and emphasises the fact that this is unusual for a species of *Heteromastus*. For this reason we feel justified in believing this to be a valid species of *Mediomastus* rather than a *species inquirenda* and have included it in Tables 1 and 2.

**Habitat.** Found in amongst oyster beds, in 2 m deep brackish water.

**Distribution.** Known only from the type locality in Sri Lanka, Indian Ocean (Fig. 12).

### *Mediomastus fragilis* Rasmussen

Figs 7g-i, 11a-f, 12; Tables 1; 2

*Mediomastus fragilis* Rasmussen, 1973: 115-116.—Rasmussen, 1956: 64-74, figs 20-23.—Warren, 1979: 757-760, fig. 1.—Capaccioni-Azzati, 1985: 50-51, figs 3-5.

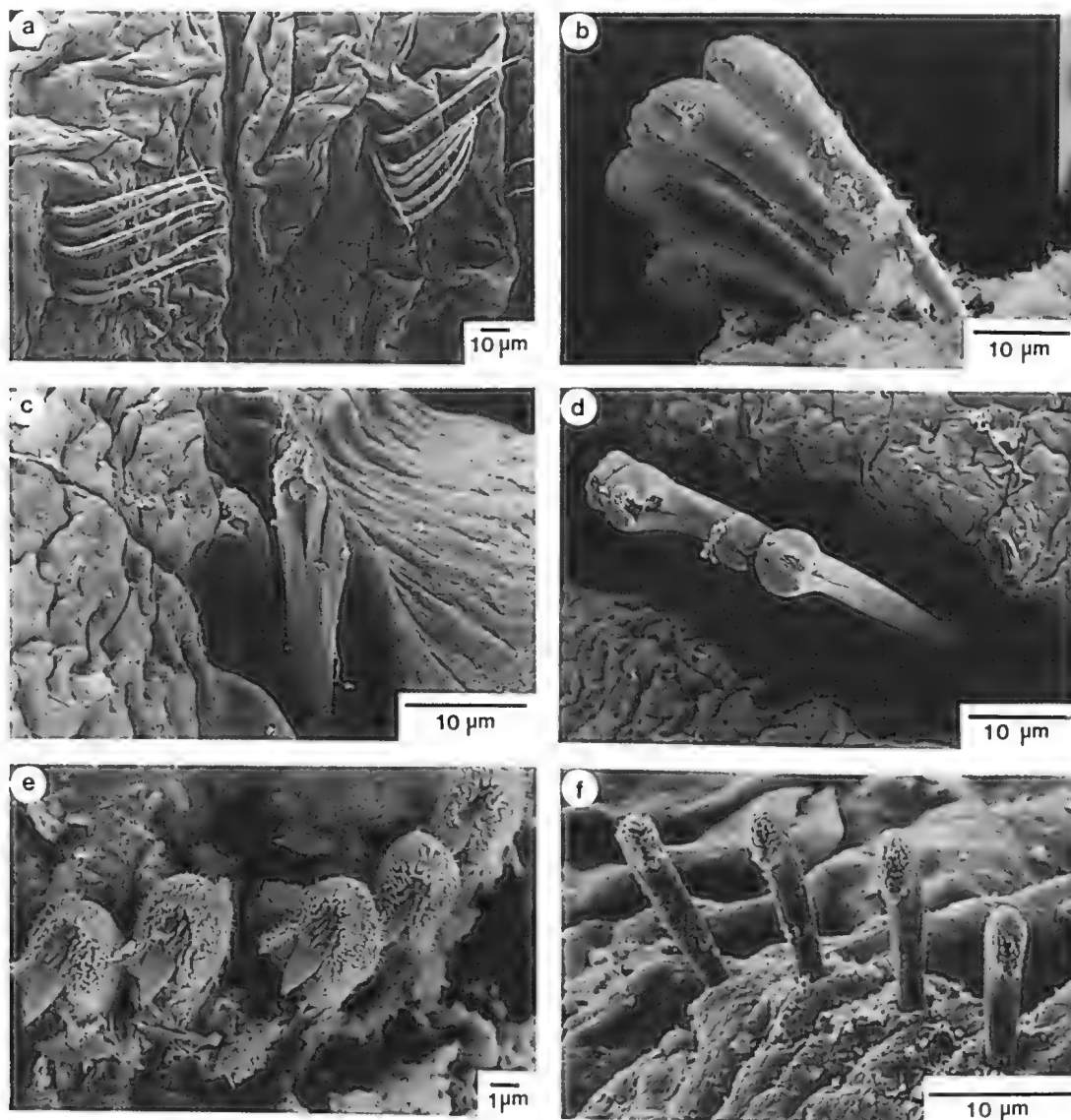
**Material examined.** Denmark – Vellerup Vig, Isefjord, 55°44'N 11°52'E, 0.5 m, silty sand, (Rasmussen's private collection from type locality). Norway – Oslofjord (BMNH ZB 1993.130.133) 59°19'N 10°30'E; England – Liverpool Bay (NMWZ 1993.060) 53°30'N 3°50'W, muddy sand/mud, 9-35 m; Grimsby (BMNH ZB 1993.134-143) 53°30'N 0°10'E; Scotland – Scalloway Voe, Shetland (BMNH ZB 1993.144-149) 60°08.5'N 01°16'W, muddy gravel near low water mark; Cambuscurrie Bay, Dornoch Firth (BMNH ZB 1993.150-155) 57°52'N 4°10'W, in fine to medium sand at low tide level, near to freshwater; Northern Ireland – Mulroy Bay (BMNH ZB 1993.121-123) 55°6'N 7°45'W. Ireland – Cork (BMNH ZB 1993.20 and 88-89) 51°40'N, 8°18'W.

**Description.** Body length to 60 mm; length of thorax to 4 mm; width of thorax to 0.8 mm. Number of segments may exceed 100. Thread-like; thorax cylindrical or tapering very slightly posteriorly. Abdomen may be coiled. Thorax/abdomen boundary indistinct, most clearly indicated by slight change in segment size and by change

in size and position of hooks. Setigers 10 and 11 may be transitional. Colourless in alcohol and often transparent. Methyl green staining did not produce any distinctive staining pattern.

Small prostomium with elongated round-tipped palpode. Eversible proboscis with low, prominent papillae. Peristomium longer than thoracic segments and not clearly marked off from first setigers. Two red eyes mid-dorsally near posterior margin (not always visible) of peristomium.

Thorax of 10 setigers; all more or less the same width; may increase in length from 0.5 times width anteriorly to 1 times width posteriorly. Segments biannulated with clear intersegmental grooves; epidermis otherwise smooth. Nephridiopores not visible. Setigers 1-4 with smooth winged capillary setae only (Fig. 11a); setigers 5-10 with hooded hooks only. Setae in 4 equally spaced fascicles just posterior to midline of segment. Number of setae per thoracic fascicle variable within and



**Fig. 11.** *Mediomastus fragilis*: a – thoracic notosetal capillary setae on setigers 3 and 4; b – thoracic hooks on setiger 5; c – thoracic notosetae on setiger 6; d – thoracic neurosetae on setiger 9; e – hooded hooks on setiger 12; f – neurosetae on setiger 22.



between individuals; capillary setae ranging from 1-11 in notopodia and 2-12 in neuropodia; range seldom exceeding 2 or 3 in an individual. Thoracic hooks range from 2-9 per fascicle in noto- and neuropodia, with similar variation present within an individual.

Thoracic hook with long, more or less straight, shaft tipped with a small fang surmounted with smaller teeth arranged in at least 2 rows with 3-5 evenly sized teeth in the first row. Constriction not apparent on thoracic hooks except, perhaps, for those on setiger 10. Hood length about 3-5 times width, tapering gradually to shaft (Figs 7g, 11b-d).

Anterior abdominal segments about same width as thoracic segments, length ranging from 0.75-1.5 times width. Length of midabdominal segments may exceed 3 times width; segments narrower than anterior segments. Posterior segments may be very small, possibly indicating regeneration. All abdominal segments multi-annulated, probably reflecting an ability to change shape. Anterior segments cylindrical; posterior segments with longer posterior margins than anterior margins, thus bell-shaped and squarish in cross section. Branchiae absent but posterior noto- and neuropodia enlarged. Pygidium smooth ring with midventral caudal cirrus.

Abdominal setigers with hooded hooks only. Fascicles positioned just posterior to mid-segment in first few setigers; in posterior third of segment thereafter and in distinct parapodial ridge around margin of segment in posterior setigers. Anterior segments with 1-3 or 3-4 hooks per fascicle even in specimens with high thoracic setal counts. Numbers may decrease to 1 per fascicle

posteriorly. It is not always possible to detect hooks in all posterior segments but hooks are known to occur to at least penultimate segment.

Abdominal hooks shorter than thoracic hooks. Shaft may show slight, indistinct constriction. Fang much larger than in thoracic hooks; surmounted by large number of very small teeth. Hood length 1.5 times width; wider than in thoracic hooks (Figs 7h-i, 11e,f).

Gravid females with large number of eggs distributed throughout body coelom. Egg diameter about 70  $\mu\text{m}$ .

**Comments.** The range in thoracic setal numbers per fascicle is much greater than for any other species of *Mediomastus*. The difference may not be significant as far more material of this species was available for detailed examination. For several other species only type material was available.

A comparison of the features of *M. fragilis* with other described species is given in Tables 1 and 2.

**Habitat.** *Mediomastus fragilis* occurs in shallow waters and intertidally in a variety of sediments but appears to prefer mud or muddy sand where it can attain densities of 1000  $\text{m}^{-2}$ .

**Distribution.** North Sea, Irish Sea and Baltic (Fig. 12). *Mediomastus fragilis* has also been recorded from the Mediterranean (Capaccioni-Azzati, 1985), but we have been unable to examine any of this material for comparison and so cannot confirm these identifications.



**Fig. 12.** Distribution of species. Species distributions are indicated by cross hatching. Species are identified by numbers, a key to which is given below. Unsubstantiated records of species have not been included. It should be noted that material of *Mediomastus* from Malaysia has been recorded but we have been unable to examine material; we have no other records from South-east Asia. 1. *M. acutus*; 2. *M. ambiseta*; 3. *M. australiensis* n.sp.; 4. *M. branchiferus*; 5. *M. californiensis*; 6. *M. calliopensis* n.sp.; 7. *M. capensis*; 8. *M. cirripes*; 9. *M. deductus*; 10. *M. fragilis*; 11. *M. setosus*; 12. *M. thomassini* n.sp.

*Mediomastus setosus* Hartmann-Schröder

Fig. 12; Tables 1, 2

*Mediomastus setosus* Hartmann-Schröder, 1959: 169-172, figs 173-177.

**Material examined.** El Salvador – Estero Jaltepeque near La Herradura, between 13°17'N 89°02'W and 13°13'N 88°54'W, TYPE (HZM P-19159) mud, intertidal, Feb. 1955, salinity 15.7 p.p.t several incomplete fragments, anterior fragment of thorax and 3 abdominal setigers, middle fragment of 5 abdominal, posterior fragment with caudal cirrus. Non-type material from type locality, gravid fragments (HZM P-15099).

**Description.** Description based on fragmented type material. Prostomium with elongated, blunt-ended palpode, proboscis papillated. Eye spots present. Thorax with asetigerous peristomium, 10 thoracic setigers. Transition from thorax to abdomen marked by an increase in length of setigers and slight change in orientation of fascicles.

Setigers 1-4 with capillary setae and setigers 5-10 with hooded hooks. Capillary fascicles with 2-4 setae in notopodia and 3-5 setae in neuropodia; hooded hook fascicles with 2-3 in notopodia and 3-5 in neuropodia. Abdominal notopodia with 3-4 hooks per fascicle and 6-9 in neuropodia.

Posterior setigers with 1 or 2 hooded hooks per fascicle, last 5 setigers in addition have 1 long seta per noto- and neuropodial fascicle, seta appears simple. Immediately prior to caudal cirrus 3 asetigerous segments. Post-setal regions of posterior setigers glandular, somewhat expanded, and posteriorly rounded. Pygidium small semi-circular, with finger shaped caudal cirrus.

No evidence of gametes was observed.

**Comments.** Hartmann-Schröder (1959) in describing this new species of *Mediomastus* had to emend the generic diagnosis to include the possession of simple setae in the notopodium of the posterior abdominal setigers. Unfortunately the type material is incomplete and the detailed structure of the simple setae in the posterior setigers cannot be determined. Thus this species must remain incompletely known and additional complete material from the type locality is needed to describe this species adequately. In the meantime we consider it to be a *species inquirenda*. However we have included the species in Tables 1 and 2.

**Habitat.** Occurs in salinities of 15.7 to 31.4 p.p.t and is not dependent upon a particular substrate; lives in tube made of fine sediment which does not completely encase the animal.

**Distribution.** Known only from the type locality in El Salvador (Fig. 12).

*Mediomastus thomassini* n.sp.

Figs 1g, 2d, 12; Tables 1, 2

*Mediomastus capensis*.—Thomassin, 1970: 80-81, fig. 5a-d (not Day, 1961).

**Type material examined.** HOLOTYPE (MNHN UC234) Stn 80, 4 Nov. 1965, 3-4 m, sandy shallow lagoonal substrate between coral patches; PARATYPES (MNHN UC235) Stn 66, 20 Oct. 1965, intertidal, sand bank; Grand Recif Barrier Reef, Tuléar, Madagascar, 23°20'S 43°41'E.

**Description.** Length 8 mm for 17 segments; length of thorax 3 mm; width of thorax 0.5 mm at setiger 2. Thorax/abdomen boundary marked by change in shape of segments, and size and position of hooks. Abdominal segments thinner-walled and variable in shape with obvious width increase posteriorly. Pale brown in alcohol; may be transparent. Methyl green staining (Fig. 2d) produced mauve-striped staining of posterior of setigers 8 and 9 and anterior and posterior of 10. Staining continued ventrally into the anterior abdomen.

Small conical prostomium with long pointed palpode. Eversible proboscis with low, widely spaced papillae; not prominent. Peristomium longer than first setiger; boundary between them indistinct. No eyes, but some scattered pigmentation on one of the paratypes.

Thorax of 10 setigers; setigers 2 and 3 slightly wider than others; length approximately 0.5-0.75 width. Boundary between segments indistinct; segments not obviously biannulated; epidermis smooth. Nephridiopores not visible. Setiger 1-4 with very long, narrowly winged capillary setae only; capillary setae flexible and whiplike; not stiff. Setigers 5-10 with hooded hooks only. Fascicles just posterior to mid-segment. Number of capillary setae range from 5-11 in notopodia and 4-8 in neuropodia; hooks range from 6-8 in notopodia and 6-10 in neuropodia. Thoracic hook with long, more or less straight, shaft tipped with a small fang surmounted by small teeth in at least 2 rows; front row with 3-5 equally sized teeth. Hood tight fitting and narrow, at least 5 times as long as wide, tapering gradually into shaft; long, narrow opening in hood.

Anterior abdominal segments slightly wider and larger than thoracic segments. Length of midabdominal segments variable but may exceed 4 times width. All abdominal segments increase in width posteriorly in region of hooks. Branchiae absent. Abdominal setigers with hooded hooks; fascicles near posterior margin of segment in all setigers. Anterior segments with 6-8 hooks per fascicle in notopodia and 7-11 in neuropodia; 15th abdominal segment with 6-7 hooks in notopodia and 16 in neuropodia. Hooks shorter than thoracic hooks. Shaft with slight but distinctive shoulder just proximal to fang; marked constriction about half way down length of shaft. Fang much larger than in thoracic hooks; down-curved at tip; beak-like; surmounted by at least 2 rows of teeth; those in first row with 3 teeth, larger than those in row above. Hood



wider distally than in thoracic hooks and shorter, length about 3 times width.

Holotype with many maturing ova, about 60  $\mu\text{m}$  in diameter but not fully rounded.

**Comments.** *Mediomastus thomassini* n.sp. can be distinguished from *M. capensis* Day, 1961 by its prominent palpode, smooth thorax without secondary annulation, distinctive capillary setae, and the marked differences between thoracic and abdominal hooks.

None of the specimens are complete posteriorly. The holotype is an anterior end with 17 segments and a midabdominal section of 17 segments; paratypes have 13 and 16 abdominal segments respectively. The lack of a posterior end means that the description cannot be complete but the material is considered sufficiently distinctive to merit the erection of a new species.

This new species can be distinguished from all other species of *Mediomastus* by the structure of the setae. The capillary setae are long, narrow and whiplike unlike those described for any other species of *Mediomastus* see Table 2. The thoracic hooded hooks have very long straight shafts, with the hood five times as long as wide and tightly fitting, and in this character they resemble those present in *M. fragilis* however this species has smooth thoracic capillaries unlike the whiplike setae present in *M. thomassini*. The abdominal hooks of *M. thomassini* are shorter than the thoracic hooded hooks and have a prominent shoulder and constriction together with a large beak-like fang and the hood is three times as long as the width of the hood. These abdominal hooded hooks are unlike those found in any other species of *Mediomastus* (see Table 2).

**Habitat.** *Mediomastus thomassini* occurs in intertidal and subtidal sand banks off the inner coral reef slope. For details of the associated fauna occurring with this species see Thomassin, 1978.

**Etymology.** The species is named after Dr Bernard Thomassin who collected the material and kindly allowed us to examine it.

**Distribution.** Known only from the type locality of Tuléar, Madagascar (Fig. 12).

### *Heteromastus* Eisig

*Heteromastus* Eisig, 1887: 839, 841-843.—Hutchings & Rainer, 1981: 373-380.

**Diagnosis.** Thorax of 12 segments; 1 asetigerous segment present; first setiger complete. Segments 2-6 with capillary setae only (ie, first 5 setigers with capillary setae only), from segment 7, all setae hooks. Notopodial branchiae present.

**Type species.** *Capitella filiformis* Claparède, 1864 by subsequent designation by Eisig (1887).

**Comments.** Hutchings & Rainer (1981) designated a neotype of *Capitella filiformis* Claparède, 1864, in order to clarify the status of the genus *Heteromastus* Eisig, 1887. This was necessary as no type material of Claparède appears to exist and some potential confusion existed between the generic diagnosis given by Eisig which is widely used and the original description of *Capitella filiformis*. For more details see Hutchings & Rainer (1981).

### *Heteromastus caudatus* (Hartman) new combination

*Mediomastus caudatus* Hartman, 1974: 237-239, fig. 13a-b.

**Material examined.** Arabian Sea – 5 km north of Cochin Harbour, Kerala State, RH14, TYPE (LACM-AHF Poly 1328), meiobenthos, 33 specimens, 23 m, silty clay, 5 March 1964; Madagascar – Tuléar, 23°20'S 43°41'E, 10 Aug. 1964, AB 363Z (LACM-AHF unregistered). intertidal sand, muddy sand, into mangrove areas; Arabian Sea 25°17'N 59°05'E, 29 Nov. 1963, AB 251B (LACM-AHF unregistered) 35 m.

**Comments.** The type material consists of a number of small worms, some of which are complete. Some of these specimens have capillary setae on the first five thoracic setigers thus complying with the diagnosis for *Heteromastus* and not *Mediomastus*. Hartman's (1974) description is not very detailed but, as far as could be determined, the specimens are those referred to in her description. The conspicuous projecting uncinal spines in the posterior segments, which she described, are clearly visible in some specimens. They take the form of greatly elongated hooded hooks with a minute head and very short hood, similar to those found in *M. ambiseta*.

The material labelled AB 251B, also referred to by Hartman in her description, consists of numerous anterior fragments.

AB 363Z is a complete worm of about 60 segments. It appears to have the correct thoracic setal formula for *Mediomastus* (although setae on setigers 1-4 could not be detected) but is not gravid. It does not come from the type locality, however. Its small size, together with the fact that it is slightly dehydrated, made it impossible to see any details of the setae but there is no sign of the uncinal projections referred to by Hartman. While this specimen may be a species of *Mediomastus*, it is not the species described by Hartman, and is in too poor a condition to describe.

We conclude therefore, that *Mediomastus caudatus* is a species of *Heteromastus*. The spine-like uncini probably mean that it is not synonymous with any described species of *Heteromastus* but we have not examined type of material of other species of *Heteromastus* to confirm this.

Recently it has been decided that the bulk of this Indian Ocean Expedition, R/V Anton Brun Cruise 4B will be lodged at the LACM-AHF with a voucher

collection being deposited in the USNM (Fauchald, personal communication).

### *Neomediomastus* Hartman

*Neomediomastus* Hartman, 1969: 392.

**Diagnosis.** Thorax with 11 segments; 1 asetigerous segment present; first setiger complete. Up to segment 7 with capillary setae only, (ie, first 6 setigers with capillary setae) then all setigers with hooks. Small notopodial branchial processes present in far posterior setigers.

**Type species.** *Mediomastus glabrus* Hartman, 1960, by original designation.

**Comments.** Hartman (1969) does not give a formal generic description of *Neomediomastus*. However as *N. glabrus* is currently the only species assigned to this genus we have based the generic diagnosis on this species. We have included a full description of *N. glabrus* based on examining type material as it was originally described as a species of *Mediomastus* and some characters were omitted from the type description.

### *Neomediomastus glabrus* (Hartman)

*Mediomastus glabrus* Hartman, 1960: 138-139.

*Neomediomastus glabrus* Hartman, 1969: 391-392, fig. 1.

**Type material examined.** HOLOTYPE (LACM-AHF Poly 0426) Stn 2850, PARATYPES (LACM-AHF Poly 0427) Stn 2850-54, 1135 m; Santa Catalina Basin, southern California, USA, 33°30'N 118°35'W. All type material posteriorly incomplete.

**Description.** Body length 5.5 mm for 33 segments; length of thorax to 2.2 mm, width of thorax 0.4 mm at setiger 3. Abdomen may be coiled. Thorax/abdomen boundary indistinct; marked by change in shape of segments. Body wall musculature thicker in thorax; abdominal segments thinner walled and not of fixed shape. There may also be marked discontinuity in segment size, first abdominal segment being wider or narrower than last thoracic segment. Abdominal notopodia are slightly lateral to thoracic notopodia. Red in alcohol, epidermis with slight sheen.

Prostomium triangular with broad base, tip rounded; no palpode. Large eversible proboscis, divided into 2 equal lobes by deep constriction. Anterior lobe slightly papillated; posterior lobe with distinct, long, pointed papillae; basal part with small papillae. Peristomium about same length and width as first setiger. Anterior margin evaginated mid-dorsally. No eyes. Thorax of 10

setigers; setigers 1-4 about one-third as long as wide; setigers 5-10 slightly narrower, length increasing gradually so that setiger 10 as long as wide. Setigers 1-4 clearly biannulated; epidermis otherwise smooth.

Nephridiopores not visible. Setigers 1-6 with capillary setae only. Capillary setae long, distally fine and flexible. Setigers 7-10 with hooks only. Setae in 4 equally spaced fascicles; dorsal capillary setae at angle such that lateral ends of notopodia are anterior to other ends. Hooks in an uneven row, appearing as double row in places. Numbers of capillary setae range from 6-13 in notopodia, 6-14 in neuropodia. Numbers of thoracic hooks range from 4-9 in notopodia; 6-11 in neuropodia.

Thoracic hook almost spine-like with long, more or less straight shaft and minute fang surmounted by indistinct rows of teeth. Hood tight fitting and long; length at least 6 times width; long narrow opening.

Size and shape of abdominal segments varies. Segment length usually 0.75-1.25 times width but may be much longer. Segments swollen dorsally, and sometimes ventrally in region of setae. Parapodial ridges increasingly more prominent after about sixth abdominal segment; notopodia each develop a posteriorly directed digitate lobe that may have branchial function.

Abdominal setigers with hooded hooks only; fascicles at mid-segment level in anterior segments, posteriorly thereafter. Anterior abdominal segments with 5-9 hooks per fascicle in notopodia; 10-11 in neuropodia; 15th abdominal segment with 6-8 hooks. Abdominal hooks shorter than thoracic hooks; shaft with a distinct shoulder but no constriction. Fang larger than in thoracic hooks; surmounted by at least 2 rows of regularly arranged, very small teeth, about 5 in each row. Hood short and tight fitting about 2 times as long as wide. Abdominal hooks are shorter.

**Comments.** None of the type specimens are complete, although Hartman (1960) refers to posterior segments. The holotype is a juvenile with only five thoracic setigers with capillary setae. None of the specimens is gravid. It is possible, therefore, that all specimens are juveniles. Nevertheless, the distinctive proboscis, the arrangement and structure of the setae; the notopodial "branchiae", together with the deep ocean habitat, suggest that the material is representative of a species sufficiently distinct from other capitellids to merit its own genus, *Neomediomastus* as diagnosed by Hartman (1969).

**Habitat.** *Neomediomastus glabrus* occurs at depths exceeding 1000 m.

**Distribution.** Deep basins and submarine canyons off southern California and western Mexico.

### Discussion

The genus *Mediomastus* occurs throughout the world except in extreme high latitudes. Species are typically

geographically isolated (Fig. 12). Morphological differences between species are small, as is typical of the family Capitellidae. Generic determination of *Mediomastus* is dependent upon the thoracic setal formula and it is essential to examine mature individuals in order to avoid the possibility of confusion with *Heteromastus* as juvenile *Heteromastus* have the same thoracic setal formula as adult *Mediomastus*.

The morphology of the posterior end of *Mediomastus* is diagnostic for some species and only complete, sexually mature individuals can therefore be determined with any certainty. Thus, ideally, only sexually mature, complete individuals should be described as type material.

We know little of the geographical variation exhibited within species of *Mediomastus* as most species are known from a few limited localities often occurring in large numbers. We consider that the morphological differences between individuals from different localities represent discrete species and not geographical variation within one cosmopolitan species. Instead *Mediomastus*, which occupies similar shallow water habitats throughout the world, appears to have evolved into a number of discrete species without undergoing extensive morphological radiation. In support of this hypothesis, it may be noted that extensive intertidal and shallow subtidal collecting in some parts of the world has failed to reveal species with widespread distributions. Rather species have discrete geographical distributions when examined in detail. Based on published material that we have examined, records of certain species outside their geographical range have been shown to be erroneous. Furthermore, the presence of morphologically similar species is common within capitellids (Doyle, 1991; Grassle & Grassle, 1976). This may be a reflection of the evolutionary consequences of the opportunistic reproductive strategies employed by certain members of this family. For example populations of *Capitella* can expand rapidly after disturbance (Grassle & Grassle, 1974). We must emphasise, however, that no detailed studies of the reproduction of *Mediomastus* have been carried out. Nevertheless, *Mediomastus* increase in numbers in response to environmental stress (Dauvin, 1982) where such a strategy would be appropriate. Another factor responsible for the presence of morphologically similar species within the family may be that most species of capitellids occupy similar habitats, ie, muddy sediments, and have similar feeding strategies etc, which restricts the need for morphological adaptations.

Electrophoretic studies may be a useful tool, for separating members of a genus by increasing the range of diagnostic characters available for consideration. Such techniques have proved useful in separating morphologically similar species of *Scyphoproctus* in Australia (Doyle, 1991).

While species of *Mediomastus* are difficult to separate, the genus is easily recognised by its body shape and form, thoracic setal formula and the presence of a caudal cirrus. It could be confused with juvenile

*Heteromastus* which may have the same thoracic setal formula (Fredette, 1982, but see also Hutchings & Rainer, 1981). *Parheteromastus* Monro, 1937 has the same number of thoracic setigers with capillary setae but has additional thoracic setigers with hooded hooks, ie, a different thoracic formula. We believe that these genera are closely related, together with *Barantolla* Southern, 1921 and *Neomediomastus* Hartman, 1969, and form a discrete group within the family. We have examined material from each of these genera and have concluded that none is synonymous with *Mediomastus*. The closest is *Parheteromastus* but there is no doubt from the type material of the type species, *P. tenuis* Monro, 1937, that the 11th setiger is part of the thorax. The material is also much larger than any of the *Mediomastus* we have examined. It is possible that the increase in the number of posterior thoracic segments as exhibited by *Parheteromastus*, is related to the development in some species of *Mediomastus* of transitional posterior thoracic segments. It is worth noting, in this respect, that the largest species of *Mediomastus*, *M. fragilis*, is transitional on setiger 11. We have not, as yet, carried out a detailed study of these similar genera and cannot, therefore, comment further on possible inter-relationships.

This review is an attempt to clarify the taxonomy of *Mediomastus* as far as is possible given the material available. It is not intended to be a definitive work. Only four species are represented by large collections from several localities; five are known only from the type locality and, of these, four are known only from a single specimen or few specimens. For several species, the type material is incomplete or badly damaged. Wherever possible we have examined representative setae under SEM because we believe that setal morphology is very useful as a diagnostic tool. It is not often practical, however, so we have based the key on other features. We must emphasise that the key is not necessarily exhaustive, but hopefully will facilitate the identification of additional material as it becomes available.

### Distinguishing between Species of *Mediomastus*

The most difficult species to distinguish between, even with good material, are *M. californiensis*, *M. capensis* and *M. fragilis*, which are all large species. *Mediomastus ambiseta*, which is also large and has a similar distribution to *M. californiensis*, is readily distinguished by the presence of capillary setae and spine-like hooks in the abdomen. As these may start from about setiger 15, the distinction should be apparent even in most incomplete worms. *Mediomastus acutus*, which also occurs in California, may be distinguished by its paddle-like notosetae and by the shape of its prostomium. *Mediomastus californiensis* and *M. fragilis* are best distinguished by the fact that the thoracic and abdominal hooks are morphologically different in *M. fragilis* but very similar to one another in *M. californiensis*. Despite its name, *M. fragilis* is the

largest, most robust species in the genus. This may explain why setiger 11 as well as setiger 10 appears transitional in some specimens. It is possible that smaller specimens might be confused with *M. thomassini*. It is difficult to make comparisons between a species known only from incomplete type material and one that is commonly occurring but, on the evidence currently available, *M. thomassini* may be distinguished by the long down-curved fang on the abdominal hooks and by the prominence of all its setae which appear unusually long relative to its body size. *Mediomastus capensis* is similarly quite difficult to distinguish from *M. californiensis* but has differences in setal morphology. Three species have abdominal capillary setae. The best known of these, *M. ambiseta*, also has spine-like hooks. As far as is known these are not present in *M. branchiferus* nor *M. setosus*. In Australia, currently two species are known which can easily be separated, *M. australiensis* is a robust species in contrast to *M. calliopensis*, in addition the structure of the hooded hooks differs.

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Table 1. Summary of diagnostic characters of species of *Mediomastus* (except setae). n.d. - no data

SPECIES	LOCALITY	LENGTH (mm)	EGG DIAMETER ( $\mu$ m)	ABD. CAPS	ABD. SPINE-LIKE HOOKS	PROSTOMIUM	PAPILLAE ON PROBOSCS	BRANCHIAE
<i>M. acutus</i>	California, USA	4 incomplete	60	-	-	long and pointed	poorly developed	-
<i>M. ambiseta</i>	North America east and west coast	14	50	+	+	small, conical	low, indistinct	-
<i>M. australiensis</i> n.sp.	south-east Australia to south Australia	21+	80	-	-	long, rounded tipped	finely papillated	-
<i>M. branchiferus</i>	South America Pacific Ocean	3.5	n.d.	+	-	small rounded palpode		+
<i>M. californiensis</i>	North America east and west coast Gulf of Mexico	35	60	-	-	small	widely scattered low, more or less distinct	-
<i>M. calliopensis</i> n.sp.	Gladstone Old, Australia	27	50-57	-	-	small	low	-
<i>M. capensis</i>	South Africa Indian Ocean	14 incomplete	40	-	-	small, elongated palpode	appears smooth, very indistinct	-
<i>M. cirripes</i>	Mediterranean	3-5, type, incomplete	65+	-	-	small, conical with long palpode	low, poorly defined	-
<i>M. deductus</i>	Sri Lanka Indian Ocean	37, type, incomplete	65	-	-	small, conical	very distinct	-
<i>M. fragilis</i>	North Sea, Baltic ? Mediterranean	60	70	-	-	small	low prominent	-
<i>M. setosus</i>	El Salvador Pacific Ocean	4	n.d.	+	-		present	-
<i>M. thomassini</i> n.sp.	Madagascar Indian Ocean	8 incomplete	60+	-	-	small conical	widely spaced, low, not prominent	-

APPENDIX



Table 2. Setal characteristics of species of *Mediomastus*. n.d. = no data; for abdominal caps and spine-like hooks + = present, - = absent; for thoracic abdominal hooks, + = same, - = different; ± = more or less the same.

SPECIES	THORAX AND ABD. HOOKS SAME	THORAX/ABD. BOUNDARY	THORACIC HOOK	ABDOMINAL HOOK	CAPILLARIES (THORACIC)
<i>M. acutus</i>	+	distinct setiger 10/11	long straight shaft paddle-like notosetae, plus hooded hooks, neurosetae different, shorter	neurosetae same as thoracic neurosetal hook, abdominal notosetae included paddle-like notosetae and typical hooded hook	short, spatulate, smooth tipped
<i>M. ambiseta</i>	-	distinct setiger 10/11, setiger 10 same shape as 9, transitional in size	long, straight shaft slight shoulder; no constriction, small fang; 2 rows of teeth; tight hood 2-5 times long as wide	short, stout shaft prominent shoulder prominent constriction hood short and wide 2-3 times long as wide	broad winged recurved tip
<i>M. australiensis</i> n.sp.	-	clear demarcation	distinct neck and shoulder; no constriction hood wide with curved opening, surface of hood textured	similar to thoracic but fang longer pointed, slightly beaked; hoods flared with upturned margins strongly textured	narrow winged capillaries
<i>M. branchiferus</i>	n.d.	damaged, n.d.	long straight shaft; no constriction; hood 3 times as long as wide	n.d.	n.d.
<i>M. californiensis</i>	±	distinct 10/11	long straight shaft, no constriction; small fang; several rows of teeth in first row, hood tight 3 times long as wide	slight shoulder, slight constriction, otherwise like thoracic	narrow smooth winged
<i>M. calliopensis</i> n.sp.	-	distinct 10/11 position of setae transitional on 10	stout, short shaft; small fang, hood wide	shorter and smaller, prominent shoulder, long fang, shorter hood	narrow smooth winged



Table 2 (cont'd).

SPECIES	THORAX AND ABD. HOOKS SAME	THORAX/ABD. BOUNDARY	THORACIC HOOK	ABDOMINAL HOOK	CAPILLARIES (THORACIC)
<i>M. capensis</i>	±	distinct 10/11 setiger 10 same size and shape as 9; setae in same position on 11	long straight shaft; small fang; 3 steep rows of teeth voluminous hood 2-3 times long as wide	slightly shorter, slight shoulder, no constriction, fang slightly larger, 2+ steep rows of teeth	hooked tip
<i>M. cirripes</i>	±	distinct 10/11 setiger 10 transitional	long straight shaft; no constriction, small fang, 3+ rows of teeth, hood wide very long and wide, 4 times long as wide	slight shoulder and constriction, fang slightly larger, hood narrower	broad winged
<i>M. deductus</i>	—	indistinct setiger 10 like 9	not prominent; no shoulder, no constriction, small fang, 4 times long as wide	very short; indistinct shoulder, prominent fang, tight hood	narrow winged, may be recurved
<i>M. fragilis</i>	—	indistinct setigers 10+11 both transitional hook intermediate	long, straightish shaft, no constriction, small fang; 2+ rows of teeth, hood 3-5 times long as wide	short indistinct constriction, larger fang, many teeth, hood one and a half times long as wide	smooth
<i>M. setosus</i>	n.d.	? distinct	n.d.	n.d.	n.d.
<i>M. thomassini</i> n.sp.	—	more or less distinct	very long straight shaft, small fang; 2 rows of teeth, first row with 3-5 teeth, hood tight; 5 times long as wide	shorter; shoulder and constriction large fang-beak-like 2+ rows of teeth; wide hood 3 times long as wide	long, narrow whiplike

## New Species belonging to the Family Porcellidiidae (Harpacticoida: Copepoda) from the Southern Coast of New South Wales, Australia

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**ABSTRACT.** Eight new species belonging to the family Porcellidiidae (Harpacticoida: Copepoda) are described from the southern coast of New South Wales, Australia. All live on the surface of seaweeds in the eulittoral and sublittoral zones. Characteristic features of the family are described and redefined. The genus *Porcellidium* is redefined and subdivided into three groups on the setation of the female caudal ramus and structure of the male antennule. Four of the new species, *Porcellidium hormosirii*, *P. ocellum*, *P. pulchrum* and *P. erythrogastrum* have been assigned to the "Hormosirii" group, and *P. naviculum* and *P. phyllosporum* to the "Naviculum" group. A new genus, *Acutiramus*, is defined and two new species, *A. rufolineatus* and *A. quinquelineatus*, assigned to it. The relationship between the new species and previously described species of *Porcellidium* is discussed. *Porcellidium viride* (Phillipi, 1840) and *P. sarsi* (Claus, 1863) are placed in the 'Naviculum' subgroup, *P. rubrum* Pallares, 1966, *P. hartmannorum* Tiemann, 1978, *P. erythrum* Hicks, 1971 and *P. algoense* Hicks, 1982 are placed in the subgroup 'Hormosirii', and *P. fimbriatum* Claus, 1889 is placed in a subgroup of its own. *Porcellidium acuticaudatum* Thompson & Scott, 1903, *P. brevicaudatum* Thompson & Scott, 1903 and *P. ovale* Geddes, 1968 (not Haller) have been placed in the new genus *Acutiramus*.

HARRIS, V.A.P. & H.M. ROBERTSON, 1994. New species belonging to the family Porcellidiidae (Harpacticoida: Copepoda) from the southern coast of New South Wales, Australia. Records of the Australian Museum 46(3): 257–301.

The family Porcellidiidae (Harpacticoida: Copepoda) has a rich assemblage of species in the marine littoral of eastern Australia. Extensive collection by the authors over the past two decades has revealed 30 new forms from New South Wales, Australia. In addition, five new

forms have been found in the subtropical waters of the Great Barrier Reef, Qld. For convenience, the NSW forms will be split into a northern assemblage characteristic of the warm temperate waters north of Sydney, and a southern assemblage characteristic of

waters influenced by the cool currents from the Bass Strait. A small number of species span both northern and southern waters of NSW. In this paper eight of the southern species will be described.

Members of the Porcellidiidae are poor swimmers. With the exception of three species (*Porcellidium echinophylum*, *P. bevicaudatum* and *P. tapui*) living in mutualistic relationship with other animals, all members of the family live on the surface of seaweed to which they adhere with remarkable tenacity. They appear to be confined to the littoral and sublittoral zones, but little is known about their vertical distribution. *Porcellidium hormosirii* is abundant at mean tide level (MTL) and *Acutiramus rufolineatus* is common at mean low water neap tides (MLWN) on NSW rocky shores. All the other species described here have been collected from the infralittoral fringe (accessible region of the sublittoral). At the other extreme, *P. tapui* has been recorded at depths of 200 m living on hermit crab shells (Hicks & Webber, 1983).

Up to the present time the family has been regarded as monotypic with all species being referred to one genus, *Porcellidium*. The reason for this is not difficult to understand. In the first place the family is remarkably conservative in its basic structure. Members are highly specialised for a particularly difficult and demanding ecological niche—dwelling on the surface of seaweed in turbulent waters. Having achieved an efficient body form and structure to exploit this niche, no significant structural changes can take place without being detrimental to this way of life. Thus in their general body form members of this family look remarkably alike.

Secondly, many authors have noted minor differences in structure or shape, most of which show continuous variation between species and are hard to quantify. Hitherto, none have fallen into the category of unique (discontinuous) characters which exist in one or more distinct forms that would allow the erection of new genera. Apart from trivial differences, members look remarkably similar.

Thirdly, the database upon which taxonomy of this group is based is very small. In many of the older descriptions familial characters are given as though they were specific characters. Of the 27 species (Hicks & Webber, 1983) of *Porcellidium* presently recognised, only eight have been completely and adequately described (*P. echinophylum* Humes & Gelerman, 1962; *P. rubrum* Pallares, 1968; *P. bevicaudatum* Thompson & Scott (Humes & Ho, 1969); *P. planum* Tiemann, 1977; *P. hartmannorum* Tiemann, 1978; *P. dilatatum* Hicks, 1971; *P. tristanense* Wiborg (Hicks, 1982) and *P. tapui* Hicks & Webber, 1983. Adequate descriptions of *P. erythrum* and *P. algoense* have been given by Hicks (1971, 1982), thus making a total database of only 10 species. The New South Wales and Great Barrier Reef material studied by the authors has increased this database to over 40 species. Consequently family, generic and specific characters can be defined with far greater confidence.

A number of unique characters have been found

which provide good criteria upon which new genera can be erected, moreover, a better understanding of the range of variation of other characters has led the way to a redefinition of the characteristics of the Porcellidiidae.

Certain features are found in all species and do not vary. Where these differ from related families (Harpacticidae, Peltidae, Tisbidae) they constitute familial characters. Unique characters which appear in two or three distinct forms without any continuous variation between them, appear to be good characters upon which to base generic relationships, while features showing a wide (and sometimes continuous) range of variation can be useful specific characters. Table 1 (Appendix) gives a list of characters that have been used in the present descriptions.

Attempts have been made in the past to devise a key to the species (Nicholls, 1941; Lang, 1948; Wiborg, 1964), but each is based upon female characters alone. However, the list in Table 1 (Appendix) clearly shows that adult males provide valuable taxonomic characters (antennule structure, cephalosome shape, setation of P2 and P5, for example), and these should be incorporated in the list of diagnostic features used to compile taxonomic keys.

The new enlarged database conflicts in many instances with characters of the family as listed by Sars (1904), Lang (1948) and other authors. This necessitates a major revision of the criteria defining the Porcellidiidae and a restatement of the characteristics of the genus *Porcellidium*. As a first step towards the revision of *Porcellidium*, the genus will be divided into three subgroups and a new genus, *Acutiramus*, erected to accommodate two new species which are excluded from *Porcellidium*.

### Type Material

For each species one sample taken from a natural population has been designated the type population, and the station from which it was collected is referred to as the type locality. Type populations were selected to contain ovigerous females, males coupled with juvenile females as well as nauplius and copepodite (copepodite) stages. Samples heavily contaminated with epizoic organisms were avoided. The location of sampling stations on the southern coast of New South Wales from which material was obtained is shown in Figure 1.

At Broulee regular sampling was carried out over a number of years, but for other stations sampling has been less frequent.

From each type population an ovigerous female has been selected as the holotype and the egg mass, which obscures the limbs, detached. A male has been selected as the allotype. The remaining type population (and in some cases other populations from the type locality) is designated paratype material. Dissected specimens were stained in chlorazol black and mounted in polyvynal

lactophenol. Drawings of limbs and body parts were made from dissection of paratype material using a Leitz Ortholux microscope with drawing tube attachment. The numbers on illustrations refer to the respective paratype slide from which they were drawn. Details of surface morphology have been obtained from scanning electron micrographs of gold coated formalin preserved specimens taken on Cambridge Stereoscan 180 and Hitachi S-255 ON scanning electron microscopes.

Holotypes, allotypes and a representative selection of paratype material (including slides) have been deposited in the Australian Museum, Sydney (AM). Other paratype material has been deposited at the British Museum of Natural History, London (BM(NH)). Other material (not paratype specimens) has been deposited in the National Museum of New Zealand, Wellington (NMNZ). The remaining paratype material and prepared slides are currently held in the Division of Botany & Zoology, School of Life Sciences, Australian National University, Canberra, Australia (ZANU), by the senior author.

Tables 1 to 4 are listed in the Appendix.

### Measurements and Terminology

Measurements were made on formalin preserved paratype specimens, care being taken not to distort the width of the body by pressure from the coverglass. To avoid error that might be caused by the angle at which the caudal rami are held, body length has been taken

as the distance from the anterior edge of the rostrum to the posterior extremity of the urosome (Fig. 2). Terms used to describe the shape of the urosome and caudal ramus as well as setae are also illustrated in Figure 2. The term spinose has been reserved for rigid or spine-like setae; plumose and annulated setae are more flexible. A hyaline fringe round the cephalosome in most species has been omitted from the drawings of the whole animal.

Estimates of abundance are subjective. They relate to a standard procedure in which copepods were washed from about four litres of each seaweed. Identification and matching males with females is greatly facilitated by the fact that adults of most species are distinctively coloured and show a marked preference for a particular species of seaweed.

### Systematics

#### Porcellidiidae Sars 1904

**Diagnosis.** Epimeral lobe of third metasomal segment reduced in female, normal in male, fourth segment without epimeral lobe; urosome comprises genital double segment plus anal segment; setae of plate-like caudal rami never longer than ramus; antennules with 6 articles in female, prehensile in male with articles 3 and 4 fused to form a compound segment; maxilliped not strongly prehensile; first pereopod (P1) with crescent of filiform setules (fimbriate crescent) on anterior aspect of endopod; setal formula (internal) for endopod of natatory limbs (pereopods P1-P4) is characteristic of the family –

Female	Male
P1 1:2	P1 1:2
P2 1:2:s.2.1	P2 1:2:s.2.1 or 1:2:s.2.0 or 1:2:0.2.0
P3 1:s.1:1:s.2.1	P3 1:s.1:1:s.2.1
P4 1:s:s.2.1	P4 1:s:s.2.1

['s' denotes a spinous seta].

All members of the family show strong sexual dimorphism.

**Adult females.** Body oval or shield shape in outline, usually strongly dorsoventrally compressed. Rostrum an inverted triangle, sometimes obscured from dorsal view. Anterior of cephalosome semicircular or truncated. Hyaline border surrounds cephalosome in most species. Epimeral lobes of metasomal segments 1 and 2 with hyaline border, lobe 3 reduced without hyaline border, segment 4 without epimeral lobe.

Urosome comprises genital double segment and anal segment only. Genital segment of urosome expanded laterally by anterior and posterior epimeral lobes in most species, but never as wide as the cephalosome. Urosome plus fifth pereopods completely cover egg mass dorsally and give rounded posterior outline to body.

Caudal rami triangular, rhomboidal or rectangular

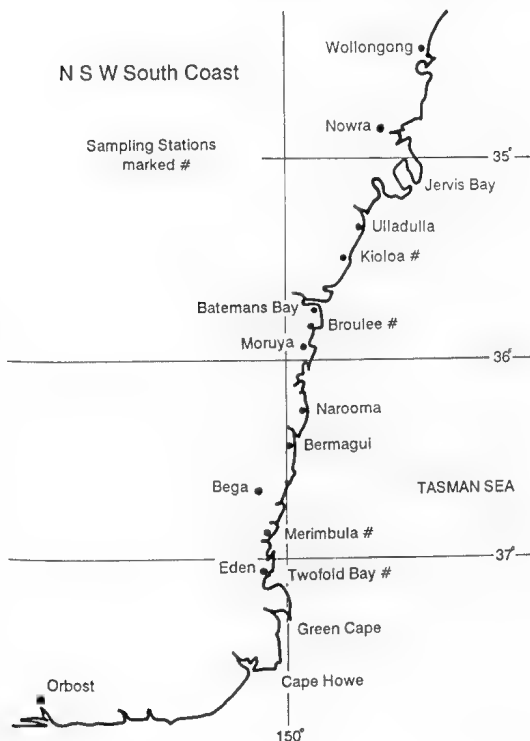


Fig. 1. Map of the New South Wales south coast showing sampling stations and type localities.

plates (never cylindrical). Caudal setae short (never longer than ramus) divisible into a dorsal series –  $\alpha$ ,  $\beta$  and  $\gamma$ , with  $\gamma$  terminal or lateral, and a terminal series of 4 (rarely 3) setae. Ramus ends in terminal fringe of

very fine setules.

Limbs. Antennule reduced to 6 articles with aesthetasc on article 4. Exopod of antenna with single article bearing 6 setae. Mandibular palp with 4 pilose setae on

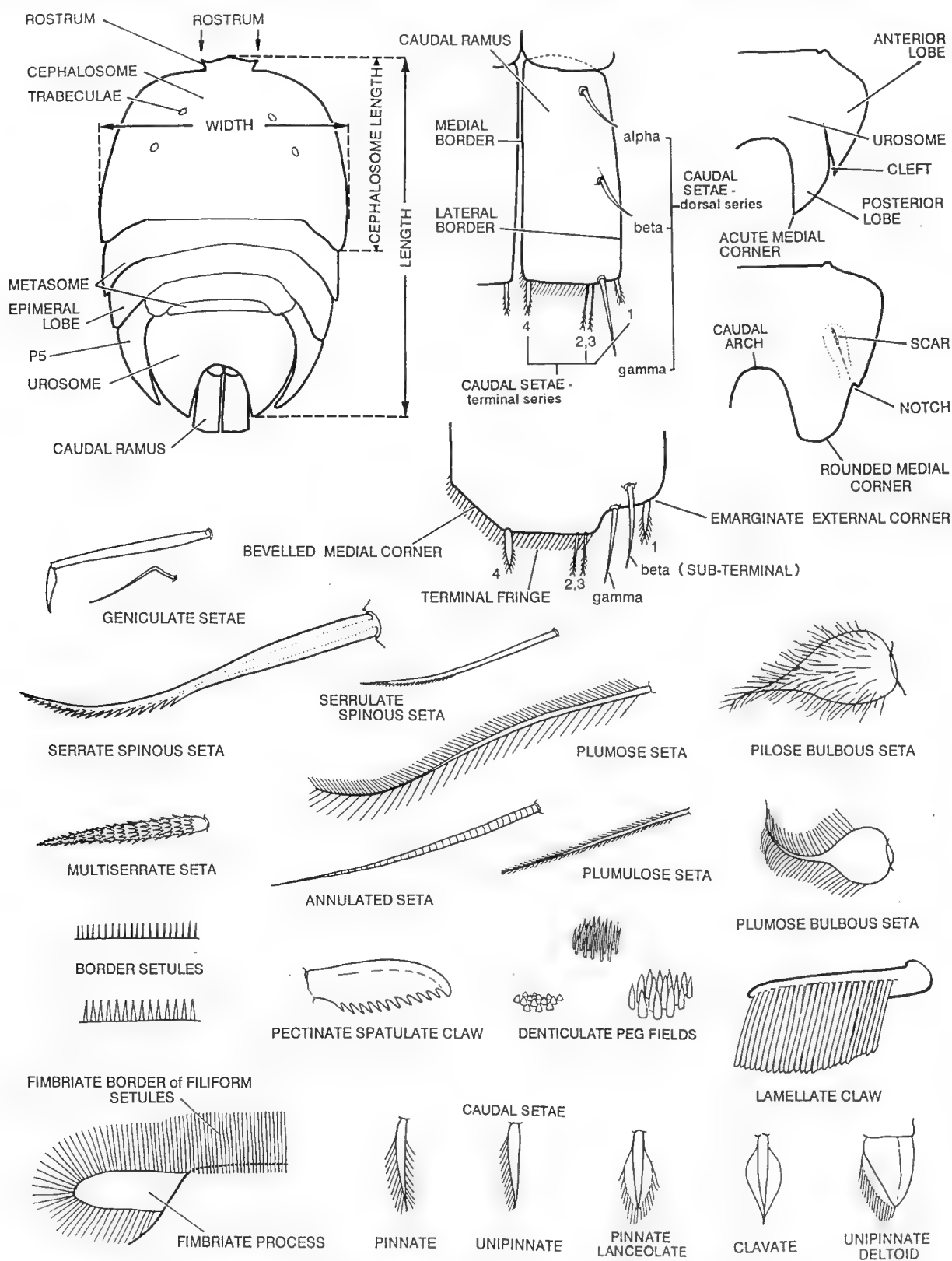


Fig. 2. Diagrams indicating method of measurement and terminology used in describing species. P5 – fifth pereopod. Numbering on the terminal caudal setae (2,3) should read 3,2.

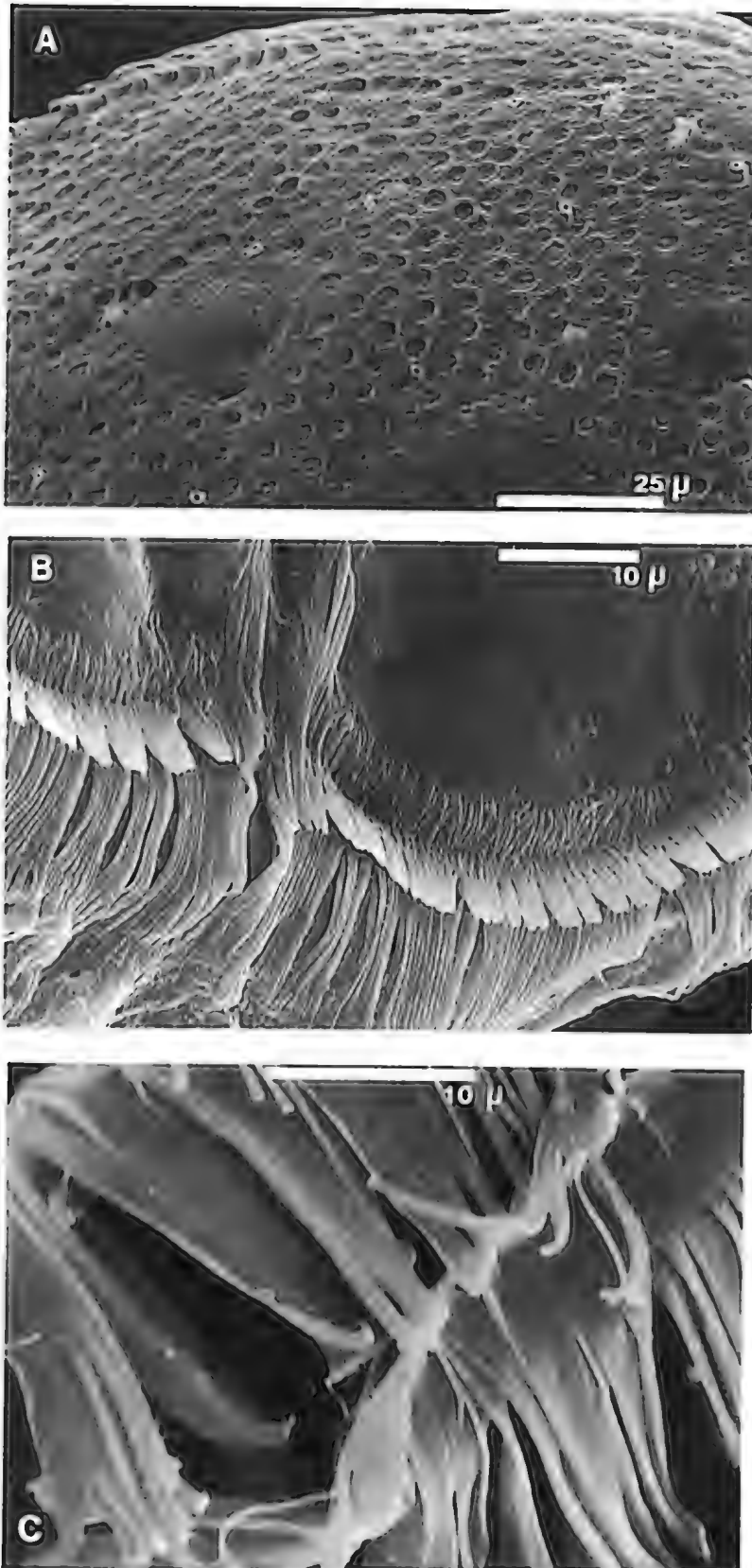


Plate 1. A – *Porcellidium hormosirii*. Dorsal pits on anteriodorsal surface of cephalosome. A few sensory setae with a collar round their base can be seen. The large oval patch to the left of centre without pits marks the position of a trabecula. SEM micrograph. Scale bar = 25  $\mu$ m. B – *Porcellidium erythrogastrum*. Part of the fimbriate crescent on P1 endopod, showing ribband-like filiform setules and proximal row of denticulate pegs. SEM micrograph. Scale bar = 10  $\mu$ m. C – terminal claws of P1 endopod showing lamellate structure of setules. SEM micrograph. Scale bar = 10  $\mu$ m.

large anterior lobe (expanded basis), 9 setae on endopod, 5 pilose and 1 plain seta plus D-shaped medial lobe on posterior lobe (exopod). Maxillule with 3 endites, endopod with 2 or 6 setae, exopod reduced, bearing 2 (occasionally one) short setae. Maxilliped reduced, not subchelate or strongly prehensile, variable, coxa with or without rounded medial plate bordered with filiform setules, basis with or without fimbriate process. Natatory limbs P1-P4 with long intercoxal (sternal) sclerite separating base of limbs, coxa-basis of limb project laterally, not ventrally. P1 exopod shorter than endopod, endopod of 2 articles, article 1 triangular with anterior crescent of filiform setules (fimbriate crescent, Pl. 1B), article 2 with 2 strong lamellate claws in most species (Pl. 1C), denticulate peg fields may be present but never on coxa-basis. Setation of natatory limbs as given in Diagnosis above. P5 exopod of 1 article, expanded, leaf-like with strong falciform ventral ridge, lies lateral to urosome (not ventral to egg mass).

**Males** Rostrum reduced, anterior of cephalosome truncated in most species, hyaline border, if present, as for female. Epimeral lobe of third metasomal segment normal with hyaline fringe, epimere absent on fourth.

Urosome not greatly expanded, narrower than female.

Caudal rami usually quadrate, usually different in shape but similar in setation to female.

Limbs. Antennules modified as prehensile organs for clasping urosome of juvenile female, articles 3 and 4 fused to form compound segment bearing coupling structures (coupling denticles); other appendages identical to female except for P2 and P5. P2 endopod setal formula variable - 1:2:0.2.0, 1:2:s.2.0 or 1:2:s.2.1 (s = spinous seta). P5 rhomboidal in most species with 1 or 6 terminal setae.

**Generic composition.** *Acutiramus* n.gen.; *Porcellidium* Claus, 1860.

**Remarks.** The majority of species are coloured and many species show sexual dimorphism in the colour pattern. Colouration and ornamentation of the dorsal surface (pits, ridges, reticulation, honeycomb etc.) are highly specific and provide useful means of identification without dissection. Many species have a specific relationship with certain epizoic organisms (suctoria, thecate ciliate protozoa and diatoms) which are an aid to identification. Nauplii are oval and extremely flattened. Copepodede (copepodite) stages take on the adult body form and pass through five stages. Metamorphosis occurs at the end of the fifth stage. Adults show strong sexual dimorphism, but the gender of juveniles can be determined at the third stage copepodede. Adult males couple with third, fourth and fifth stage juvenile females.

The family has many features in common with certain members of the Harpacticidae (*Zaus*), Peltidae (*Alteutha*, *Dactylopusia*) and Tisbidae (*Aspidiscus*, *Psamathe*), but the diagnostic characters listed above (taken as a whole) are unique and clearly distinguish members of the Porcellidiidae.

## *Porcellidium* Claus 1860

**Diagnosis.** Anterior of female cephalosome semicircular, male truncated; hyaline border and dorsal pits present; urosome broad, with epimeral expansions to form anterior and posterior lobes, posterior lobe broad, caudal rami included in caudal arch of urosome; caudal rami rectangular or quadrate,  $\alpha$  and  $\beta$  setae not close together; maxillule endopod with 6 setae; maxilliped basis with fimbriate process, coxal lobe fimbriate; male P2 endopod with 2 plumose terminal setae; male P5 with 6 terminal setae; female P5s do not extend beyond the caudal rami or touch one another posteriorly.

**Females.** Anterior outline of cephalosome semicircular with prominent rostrum, no medial bulge (convexity) or overhang above rostrum. Hyaline border always present on cephalosome and metasomal epimera. Ducts from marginal glands open dorsal to hyaline border. Dorsal pits usually conspicuous, but may be reduced or absent.

Large lateral epimeral expansions of urosome, forming distinct anterior and posterior lobes. Urosome broad. Posterior lobe rounded, not V-shaped. Marginal setules border lateral edges of urosome. Caudal arch accommodates part, if not most, of the caudal rami.

Caudal rami quadrate or rectangular, external corner may be emarginate (recessed), but posterior border is never oblique.  $\alpha$  and  $\beta$  setae never close together (ie, ratio  $\alpha$  to  $\gamma/\alpha$  to  $\beta < 5$ ),  $\beta$  usually about middle of ramus but may be subterminal (ie, close to  $\gamma$ ). Terminal setae 2 and 3 typically plain, slender and close together.

Maxillule endopod with 6 setae. Maxilliped with filiform setules bordering rounded coxal lobe and edge of basis, fimbriate process present. P1 without conspicuous or extensive denticulate peg fields on endopod. P5 lanceolate or ovate, not rounded or truncated posteriorly. Fifth limbs do not reach beyond the urosome or touch posteriorly.

**Males.** Anterior outline of cephalosome truncated, usually with medial convexity. Hyaline border and dorsal pits as for female.

Urosome without lateral expansions or marginal setules, caudal arch shallow.

Caudal rami quadrate, setation as for female.

First pilose seta on mandibular palp slender. P2 endopod with 2 plumose setae on terminal article, spinous seta absent ( $P2 = 1:2:0.2.0$ ). P5 rhomboid with 6 terminal setae.

**Species composition.** 'Hormosirii' sub-group: *Porcellidium rubrum* Pallares, 1966; *P. hartmannorum* Tiemann, 1978; *P. algoense* Hicks, 1982; *P. hormosirii* n.sp.; *P. ocellum* n.sp.; *P. pulchrum* n.sp.; *P. erythrogastrum* n.sp.

'Fimbriatum' sub-group: *Porcellidium fimbriatum* Claus, 1889.

'Naviculum' sub-group: *Porcellidium viride* (Philippa, 1840); *P. sarsi* (Claus, 1863); ? *P. erythrum* Hicks, 1971; *P. naviculum* n.sp.; *P. phyllosporum* n.sp.



**Remarks.** There is considerable variation in the shape of the urosome as well as the shape and setation of the caudal rami, moreover, a ventral blade may or may not

be present on the male antennule. Because of this members of this genus will be divided into three subgroups as follows:

1. Ventral blade present on male antennule —
  - Terminal setae 2 and 3 of caudal rami very close together, plain, fine ..... 'Hormosirii' subgroup
  - Terminal setae 2 and 3 of caudal rami not very close, resemble 1 and 4, pinnate, thick ..... 'Fimbriatum' subgroup
2. No ventral blade on male antennule ..... 'Naviculum' subgroup

### 'Hormosirii' subgroup

#### *Porcellidium hormosirii* n.sp.

Figs 3-6

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35432; ALLOTYPE adult male, AM P35433; PARATYPES 3 ovigerous females, 3 adult males, 1 coupled stage III, 1 coupled stage IV female copepodites, AM P35434. A second population has been designated paratype material [Cr.16] taken from *Hormosira banksii* at Cronulla, Sydney, NSW, 21 Aug. 1975, V.A.P. Harris, AM P35435. Four females and 3 males [Ki.24] paratypes BM(NH) 1992.383-389, (other material [Aw10] BM(NH) 1992.390-399). Dissections from which illustrations were made have been designated paratype material (slides 1159, 1348 male, 1160, 1167 female); these and remaining type population held at ZANU, registration Po.F.[Ki.24] [total type population 164 females (62 carrying eggs), 159 males (106 coupled to juvenile females), 148 uncoupled juveniles]. Taken from *Hormosira banksii* at midtide level on rocky shore, O'Hara Head, Kioloa, NSW (35°32'S 150°24'E), 24 Nov. 1976, V.A.P. Harris.

**Diagnosis.** *Adult female.* Amber yellow; mean length 0.68 mm, rostrum width 0.1 mm, ratio of cephalosome width to rostrum 4.5; dorsal surface conspicuously pitted; urosome broad, side of anterior lobe almost straight, posterior lobe rounded, medial corner rounded, small notch and scar; caudal rami rectangular, emarginate, medial corner bevelled with seta 4 set in,  $\alpha$  seta short and thick,  $\beta$  closer to  $\gamma$  than  $\alpha$ , terminal setae finely pinnate; small triangular peg field on endopod of P1; apex of P5 pointed.

*Adult male.* Antennule socket obscured, shoulders acutely angular; antennule with bifid ventral blade.

**Dimensions.** *Females.* Mean length 0.68 mm (SD = 0.011, N = 16), cephalosome length 0.37 mm, width 0.45 mm (SD = 0.018), height 0.11 mm, body length to width ratio 1.55. Rostrum 0.1 mm wide, ratio of body width to rostrum 4.5. Urosome width to length ratio 1.53. Caudal ramus length to width ratio 1.7.

*Males.* Mean length 0.5 mm (SD = 0.02, N = 16), Cephalosome length 0.28 mm, width 0.36 mm, height 0.1 mm, ratio of body length to width 1.38.

**Adult female** (Fig. 3A). Anterior outline of cephalosome semicircular, rostrum prominent, projects about 0.02 mm with hyaline edge (Fig. 3D). Hyaline border of cephalosome and epimeral lobes 7  $\mu$ m wide. Dorsal surface of cephalosome, metasome, and urosome conspicuously pitted (Pl. 1A). Pits 3  $\mu$ m in diameter with distinct crescentic border, in some areas cuticle between pits is raised to form a reticulate pattern. Reticulate pattern on dorsal surface of caudal rami.

Urosome broad (Fig. 4A), lateral edge of anterior lobe almost straight, bordered with fine setules, posterior lobe rounded with medial corner rounded and bordered with stronger setules, small notch and scar between lobes. Caudal arch deep (one-third length of urosome).

Caudal ramus rectangular slightly broader distally (Fig. 4B), medial edge straight, external corner emarginate, medial corner bevelled with seta 4 set in from corner.  $\alpha$  seta thick in comparison with other species,  $\beta$  closer to  $\gamma$  seta, terminal setae 1-4 finely pinnate and similar in size, 2 and 3 close together, terminal fringe of very fine setules ventral to setae extends from seta 2 to medial corner of ramus. In their natural position the rami do not project more than one-third of their length beyond the caudal arch of urosome.

Antennule (Fig. 3B) has the setal formula —

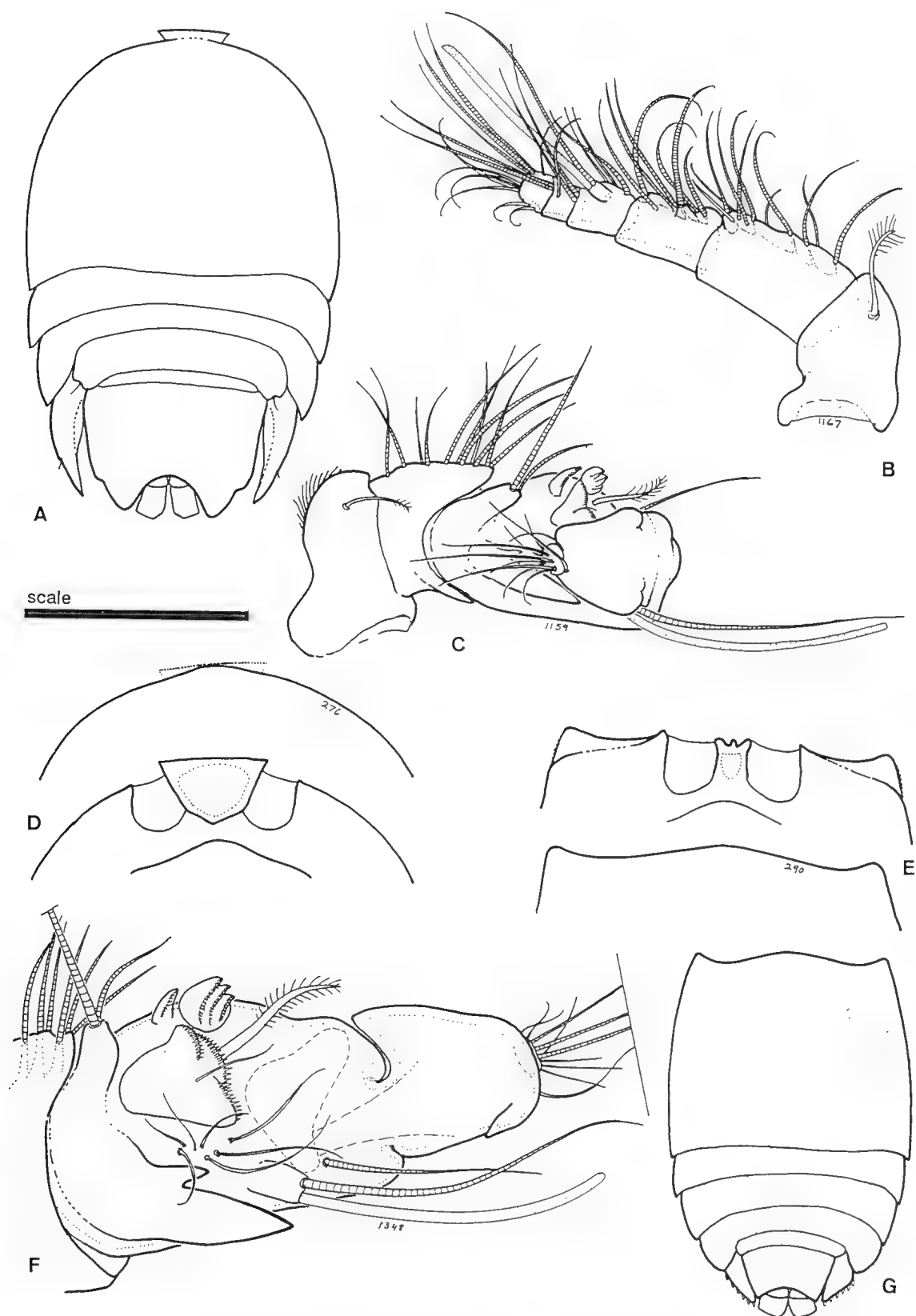
$$\frac{1}{1} : \frac{11}{2} : \frac{7}{3} : \frac{5+(As+1)}{4} : \frac{3}{5} : \frac{10}{6}$$

(As = aesthetasc)

Seta on first article plumose, remaining setae annulate. An aesthetasc (As) with accompanying seta is borne on a short lobe on article 4.

Antenna (Fig. 5B) with diagonal row of setules on basis, exopod with 6 plumose setae, article 2 of endopod with pair of plain setae plus 6 terminal setae comprising terminal pectinate spatulate claw, 3 geniculate setae with serrulate terminal portion, 2 plumose flexible setae and a small aesthetasc.

Mandible (Fig. 5A) with strong triangular pars molaris (praecoxa) tapering to the tooth-bearing incisor process with a fine seta on its anterior surface and a lacinia that is bilobed on one mandible and single lobed on the other (Fig. 5D). Coxa-basis of palp expanded anteriorly with 4 swollen pilose setae along its border and a circular



**Fig. 3.** *Porcellidium hormosirii*. A – adult female, dorsal view; B – female antennule; C – left male antennule (ventral view) with terminal segment in clasp position; D – anterior edge of female cephalosome (dorsal and ventral focus); E – anterior edge of male cephalosome (ventral and dorsal focus); F – antennule with ‘palm’ open to show coupling denticles and ventral blade; G – adult male, dorsal view. Scale bar: A,G = 0.315 mm; B,C = 0.075 mm; D,E = 0.2 mm; F = 0.045 mm.

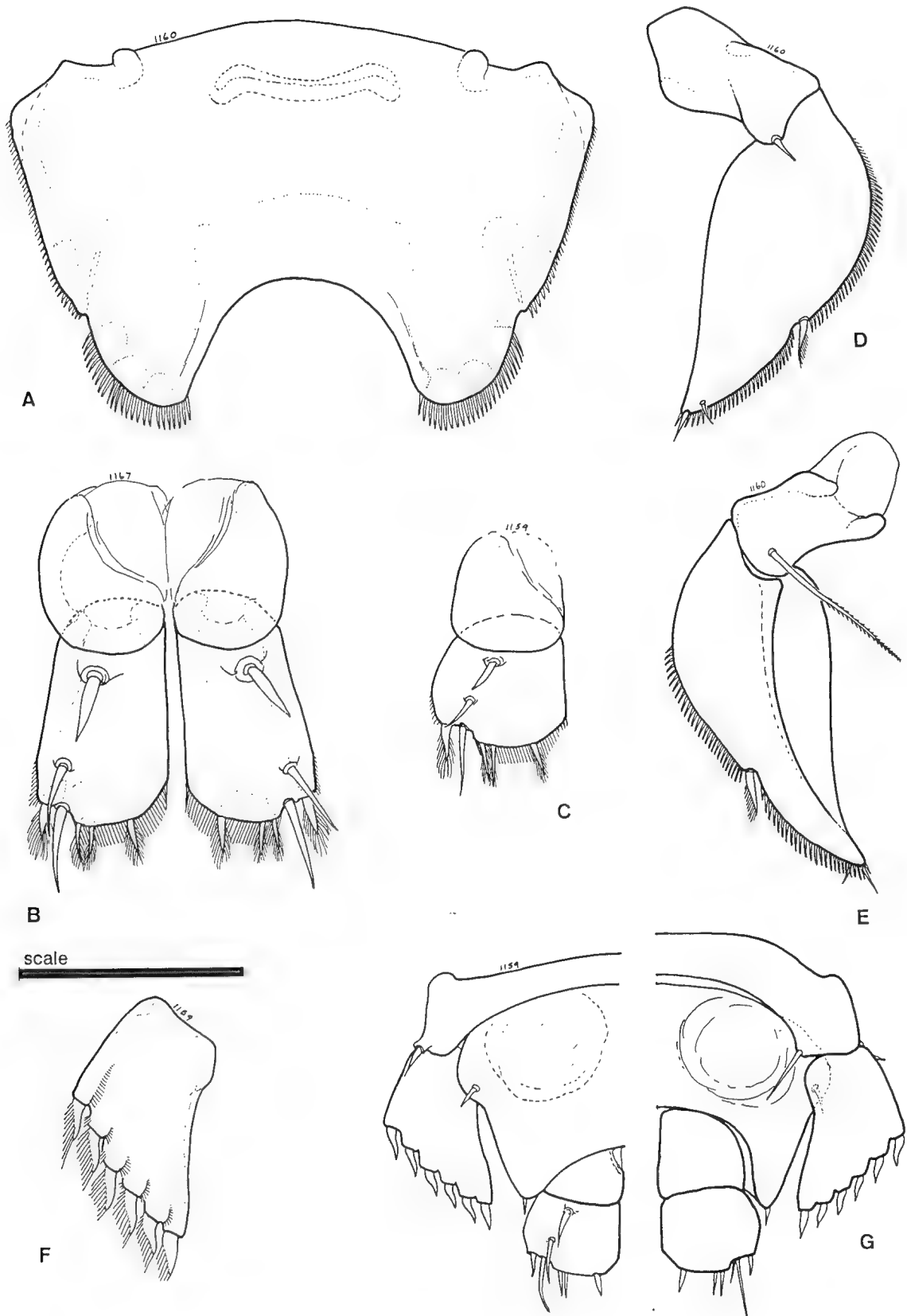


Fig. 4. *Porcellidium hormosirii*. A – female urosome; B – female caudal rami; C – male caudal ramus; D,E – female P5 (dorsal and ventral); F – male P5; G – male urosome (dorsal and ventral). Scale bar: A,D,E,G = 0.1 mm; B,C,F = 0.075 mm.

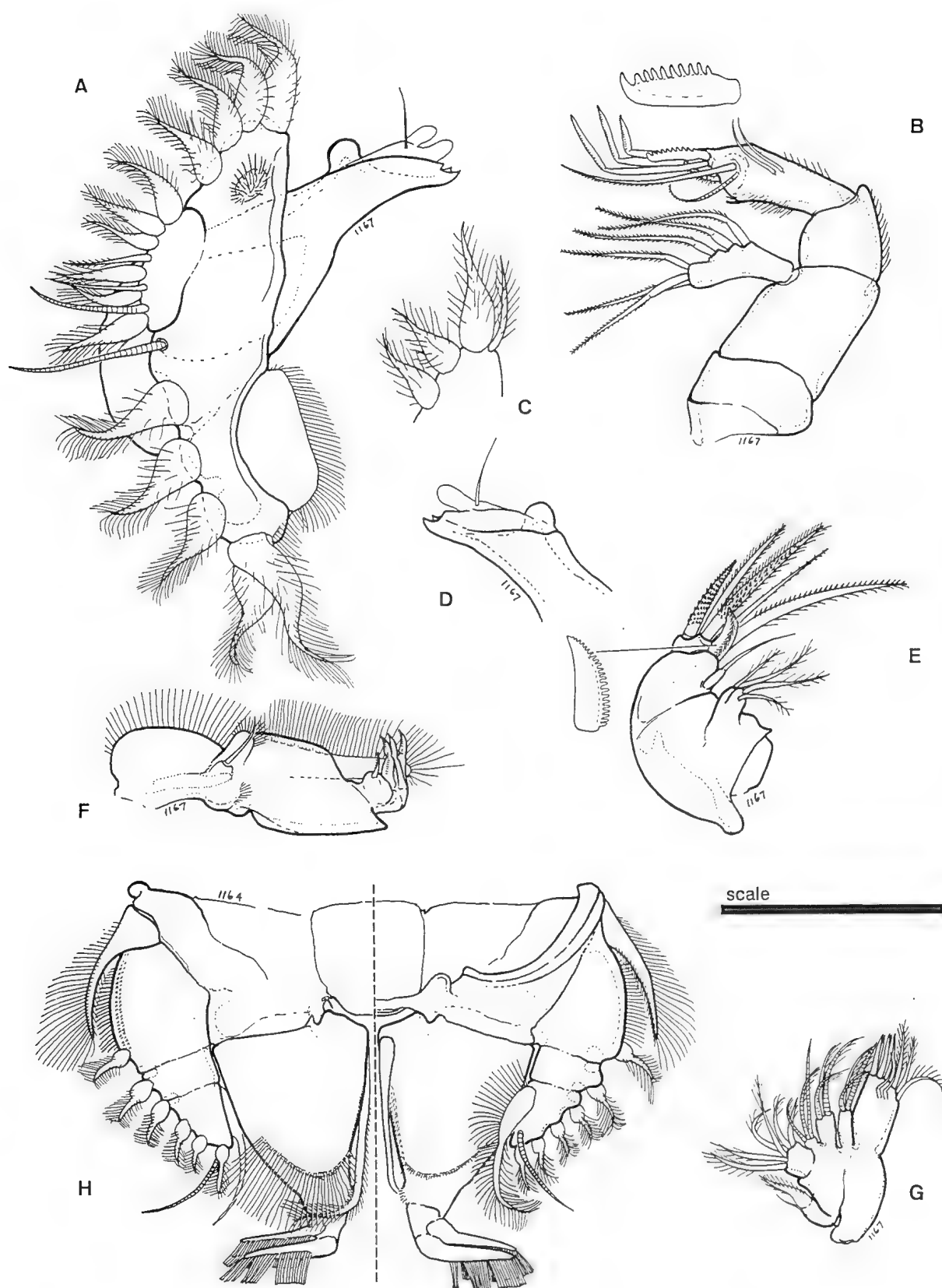


Fig. 5. *Porcellidium hormosirii*. A – left female mandible; B – antenna, inset – spatulate claw; C – male mandibular palp; D – right incisor process; E – maxilla, inset – spatulate claw; F – maxilliped; G – maxillule; H – P1, anterior – left, posterior – right. Scale bar: A-G = 0.075 mm; H = 0.1 mm.

patch of setules on ventral surface. An annulated coxal seta is located posterior to the endopod. Endopod with 9 setae (6 swollen pilose setae, 1 annulated seta, 2 plain setae). Posterior lobe of palp (exopod) with 5 swollen pilose setae along border and medial plate

bordered with filiform (hairlike) setules.

Maxillule (Fig. 5G) with prominent gnathobase to praecoxa armed medially with 5 short stout setae plus 3 plumulose setae, 2 fine geniculate setae laterally. Coxa-basis bears 3 endites each armed with 3 setae, endopod

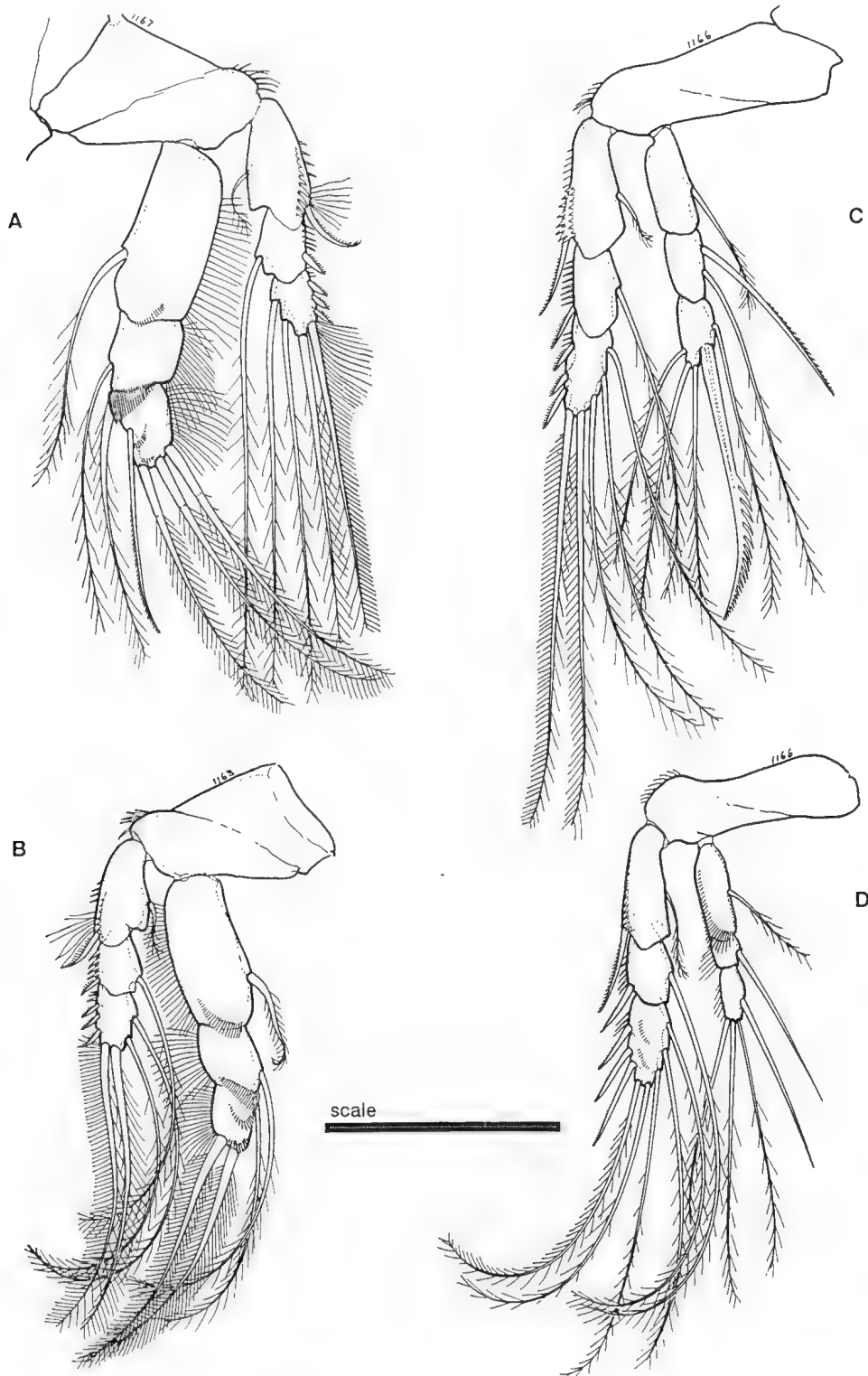


Fig. 6. *Porcellidium hormosirii*. A – female P2; B – male P2; C – P3; D – P4. Scale bar: A-D = 0.1 mm.

with 6 plumulose setae, small exopod with swollen pilose seta plus small plain seta.

Maxilla (Fig. 5E), proximal endite of praecoxa bearing 4 setae, distal endite with single seta; coxa-basis bears one short spatulate claw with pectinate edge and 1 large serrulate spinous seta, terminal endopod with 2 multiserrate and 2 serrulate spinous setae.

Maxilliped (Fig. 5F), medial coxal lobe rounded with fimbriate edge (ie, fringed with long filiform setules), single small coxal seta, ventral edge of elongate basis fimbriate, continued distally as flat oblong fimbriate process, short geniculate claw plus seta on basis, 2 geniculate claws on reduced endopod.

First pereopod (P1) characteristic of family (Fig. 5H). Intercoxal plate quadrate with small medial coxal seta, basis with small lateral tubercle and strong pilose claw-like lateral seta. Exopod proximal article bordered with filiform setules and crescent of fine denticulate pegs parallel to edge, single bulbous pilose seta on articles 1 and 2, article 3 with 4 bulbous pilose setae, annulate terminal seta and plumose internal seta lying dorsal to the endopod (Fig. 5H, right-hand side, anatomically posterior). Endopod of 2 articles; proximal article broadly triangular with strap-like plumose internal seta and band of very fine setules down internal edge, ventral surface (anterior) with fimbriate crescent comprising a double row of denticulate pegs and long ribbon-like filiform setae (Fig. 5H, left-hand side and Pl. 1B), distal article with 2 lamellate claws (Pl. 1C).

Endopod of P2 (Fig. 6A) broad and about one and a half times length of exopod; terminal article of endopod with serrulate spinous seta plus 3 plumose setae. A triangular incised subulate fringe lies at the distal end of article 2. Endopod of P3 (Fig. 6C) with serrulate spinous seta on article 2, large (sabre like) serrate spinous seta on article 3 longer than endopod (1.3:1), remaining setae plumose. Proximal article of P4 endopod with ventral band of setules (Fig. 6D), seta of article 2 and first seta of article 3 plain spinous, remaining setae plumose.

Fifth pereopod (P5) (Fig. 4D,E), coxa-basis with short dorsal seta and longer ventral serrulate seta. Distal article (exopod) broadly lanceolate with strongly sclerotised falciform ventral ridge, lateral edge bordered with strong setules, 1 lateral unipinnate seta halfway along edge and 2 apical setae. Apex of P5 does not reach beyond middle of posterior lobe of urosome.

**Adult male** (Fig. 3G). Anterior outline of cephalosome a truncated ellipse, slightly convex in midline obscuring lateral angle of antennule socket, shoulders acutely angular (Fig. 3E). Hyaline border and dorsal pits as in female.

Urosome without extensive lateral expansions (Fig. 4G), not divided into distinct anterior and posterior lobes, dorsolateral seta present, single apical setule.

Caudal ramus short, almost quadrate (Fig. 4C), setation as for female.

Antennule (Fig. 3C,F) modified as prehensile organ. Coupling apparatus on compound segment (3+4)

comprises 3 coupling denticles located on the anterioventral face; 1 triangular medial denticle with serrulate distal edge and central seta, 1 small flat proximal denticle with pectinate edge and 1 spherical distal denticle with 3 serrated ridges, a strap-like plumose seta projects from among the denticles. A blade-like sclerite (the ventral blade) projects from the joint between article 2 and the compound segment, and it is associated with an anterior protuberance bearing 2 setae (Fig. 3F). The ventral blade of *P. hormosirii* is unique in being bifid. A small lobe bearing an aesthetasc plus attendant seta originates from the ventral surface of the compound segment. The distal portion of the antennule bears 2 + 9 terminal setae and forms a prehensile digit with which to clasp the urosome region of a juvenile female.

Anterior lobe of mandible with 1 slender and 3 swollen pilose setae (Fig. 5C), other setae as for female.

P1, P3 and P4 as for female. Terminal article of P2 endopod with 2 plumose setae (Fig. 6B). P5 (Fig. 4F) rhomboid with 6 unipinnate setae along posteriolateral border; base of each seta associated with short row of setules on ventral surface.

**Remarks.** *Porcellidium hormosirii* occurs higher in the eulittoral than any other known species of *Porcellidium*. It is found as high as Mean Tide Level on *Hormosira banksii*, which dominates the midlittoral zone on rocky NSW shores, and has been named after this seaweed. It is also found in the infralittoral fringe on low level *Hormosira*, and less frequently on *Ecklonia*, *Colpomenia*, *Lobophora* and *Sargassum*.

**Distribution and abundance.** This species has the widest known range for any species in NSW; it is equally abundant from Ballina in the north to Eden in the south. It has also been recorded from Victoria (H. Robertson). High population densities (100+) are found at all seasons of the year.

### *Porcellidium ocellum* n.sp.

Figs 7-10

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35436; ALLOTYPE adult male without spermatophore, AM P35437; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35438; 4 female and 4 male paratypes [Br 82] BM(NH) 1992.400-407 (other material [Br71] BM (NH) 1992.408-417). Dissections from which illustrations were made have been designated paratype material (slides 1128 1233 1234 male, 1143 female); these and remaining type population held at ZANU, registration Po.R.[Br.82] [type population 104 females (88 carrying eggs), 117 males (17 coupled to juvenile females). Taken from *Ecklonia radiata* in the infralittoral fringe at edge of Broulee rock platform, NSW (35°52'S 150°11'E), 14 Sept. 1982, V.A.P. Harris.

**Diagnosis.** *Adult female.* Almost colourless, antennule

socket red, typically dorsal red patch on metasomes 1 and 2; mean length 0.67 mm, rostrum width 0.12 mm, ratio of cephalosome width to rostrum 3.6; dorsal surface inconspicuously pitted; urosome edge of anterior lobe slightly concave, lateral notch present, medial corners not rounded; caudal rami divergent, rectangular, medial corner not bevelled, lateral corner emarginate; setae 1 and 4 pinnate,  $\beta$  midway between  $\alpha$  and  $\gamma$  seta; no peg field on article 1 of P1 endopod:

apex of P5 pointed.

*Adult male.* Distal corner of antennule socket prominent, shoulder rounded; ventral blade and anterior spine present on antennule.

**Dimensions. Females.** Mean length 0.67 mm (SD = 0.021, N = 12), cephalosome length 0.39 mm, width 0.43 mm (SD = 0.014), height 0.1 mm, body length to width ratio 1.5. Rostrum 0.12 mm wide, projects about 0.03

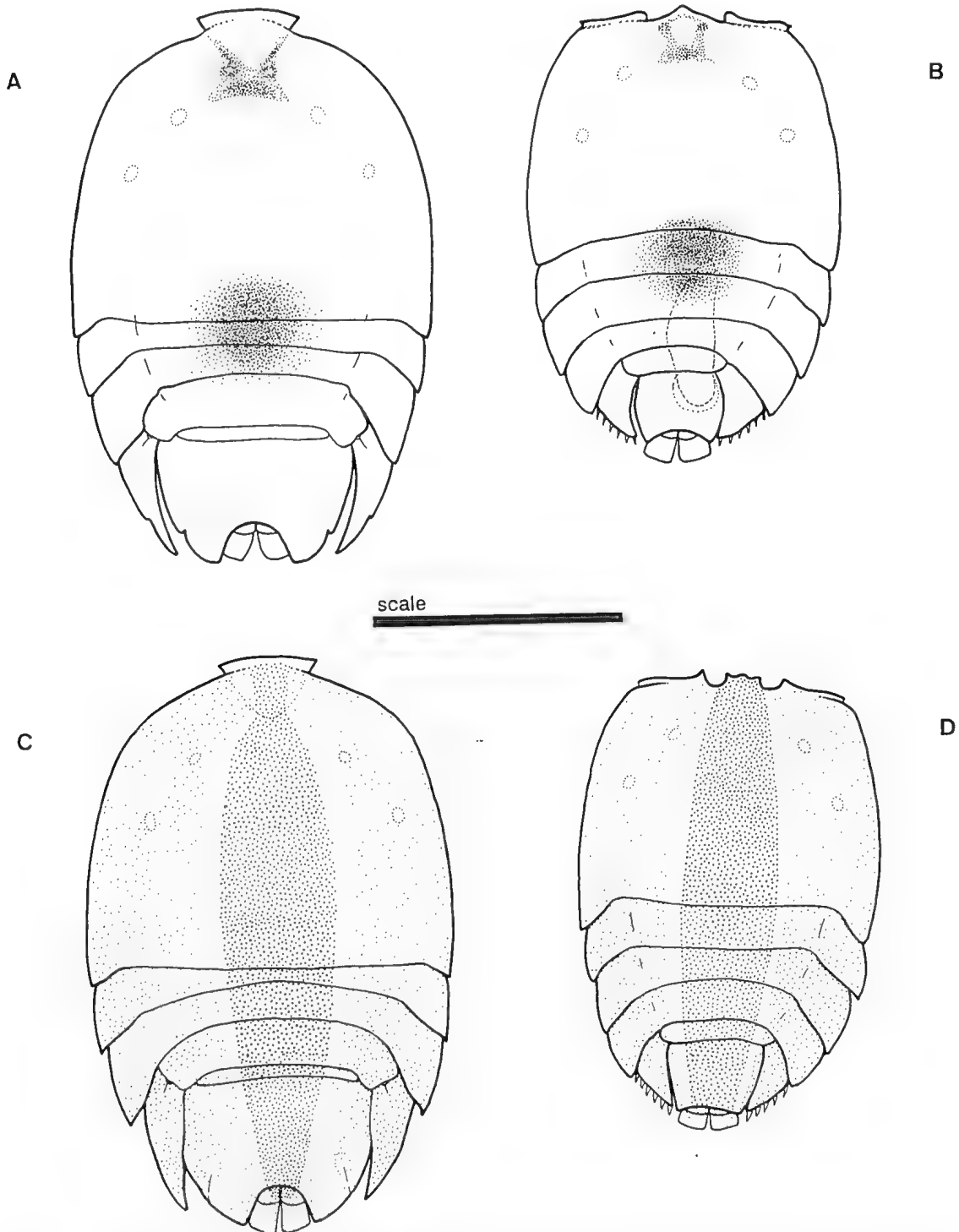
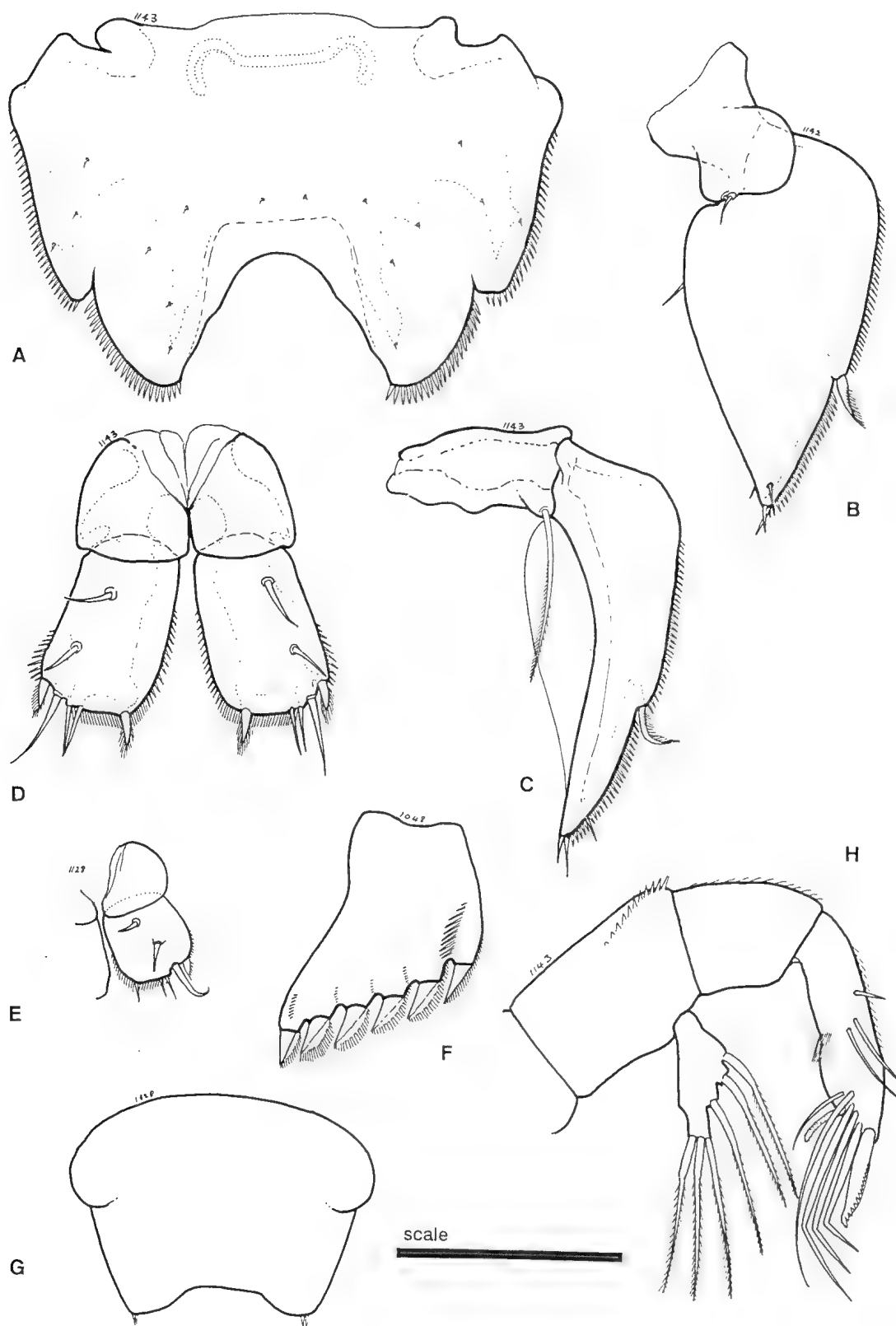


Fig. 7. *Porcellidium ocellum*. A – adult female, dorsal view; B – adult male, dorsal view. *Porcellidium pulchrum*; C – adult female, dorsal view; D – adult male, dorsal view. Scale bar: A-D = 0.315 mm.





**Fig. 8.** *Porcellidium ocellum*. A – female urosome; B,C – female P5 (dorsal and ventral); D – female caudal rami; E – male caudal ramus; F – male P5; G – male urosome (dorsal); H – antenna. Scale bar: A,B,C,E,G = 0.1 mm; D,F = 0.075 mm; H = 0.055 mm.

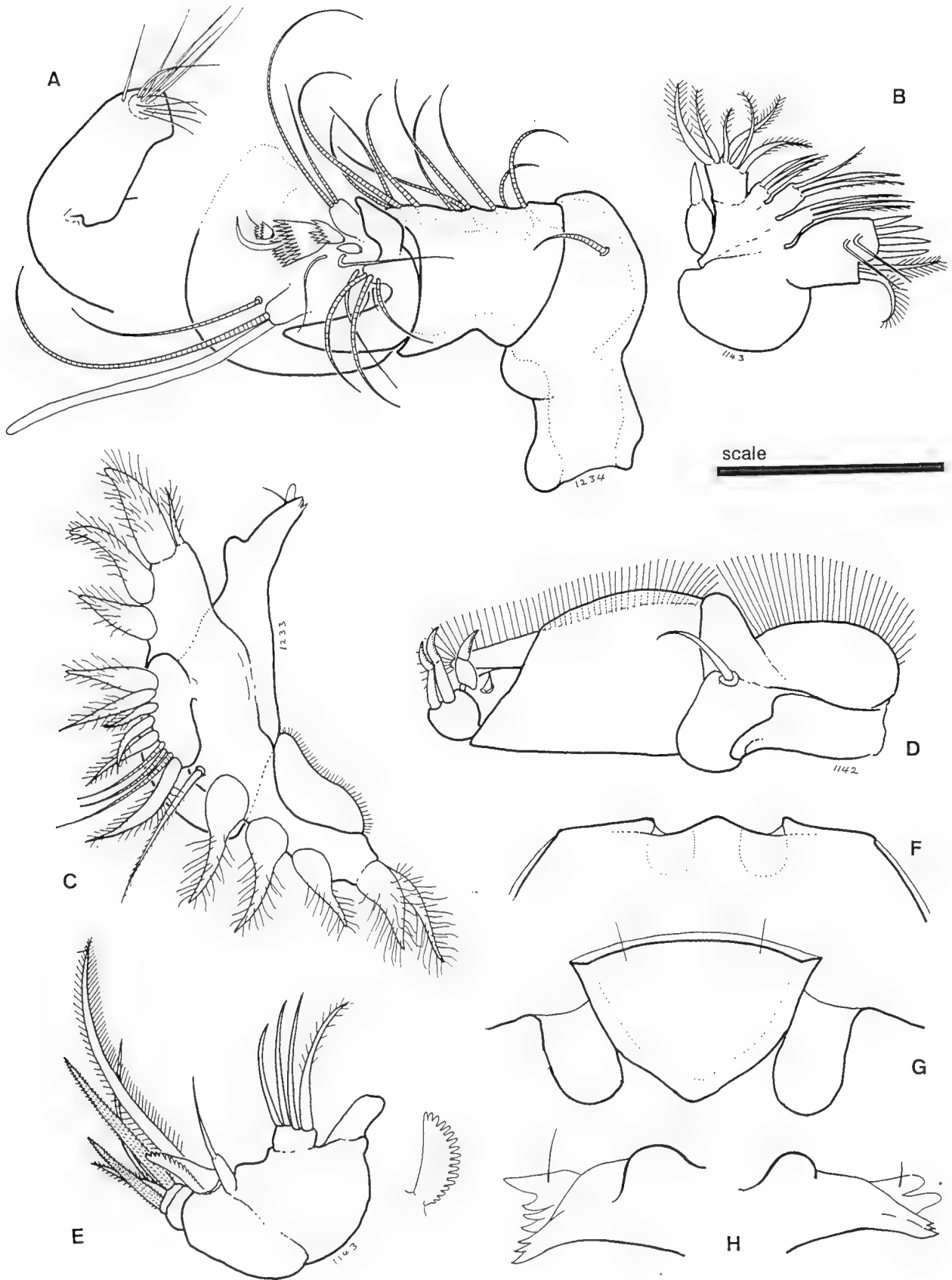


Fig. 9. *Porcellidium ocellum*. A – male antennule, terminal section displaced to show coupling denticles; B – maxillule; C – male mandible; D – maxilliped; E – maxilla; F – anterior of male cephalosome; G – female rostrum (ventral); H – detail of incisor process. Scale bar: A,E = 0.065 mm; B = 0.055 mm; C,G = 0.1 mm; D,H = 0.05 mm; F = 0.2 mm.

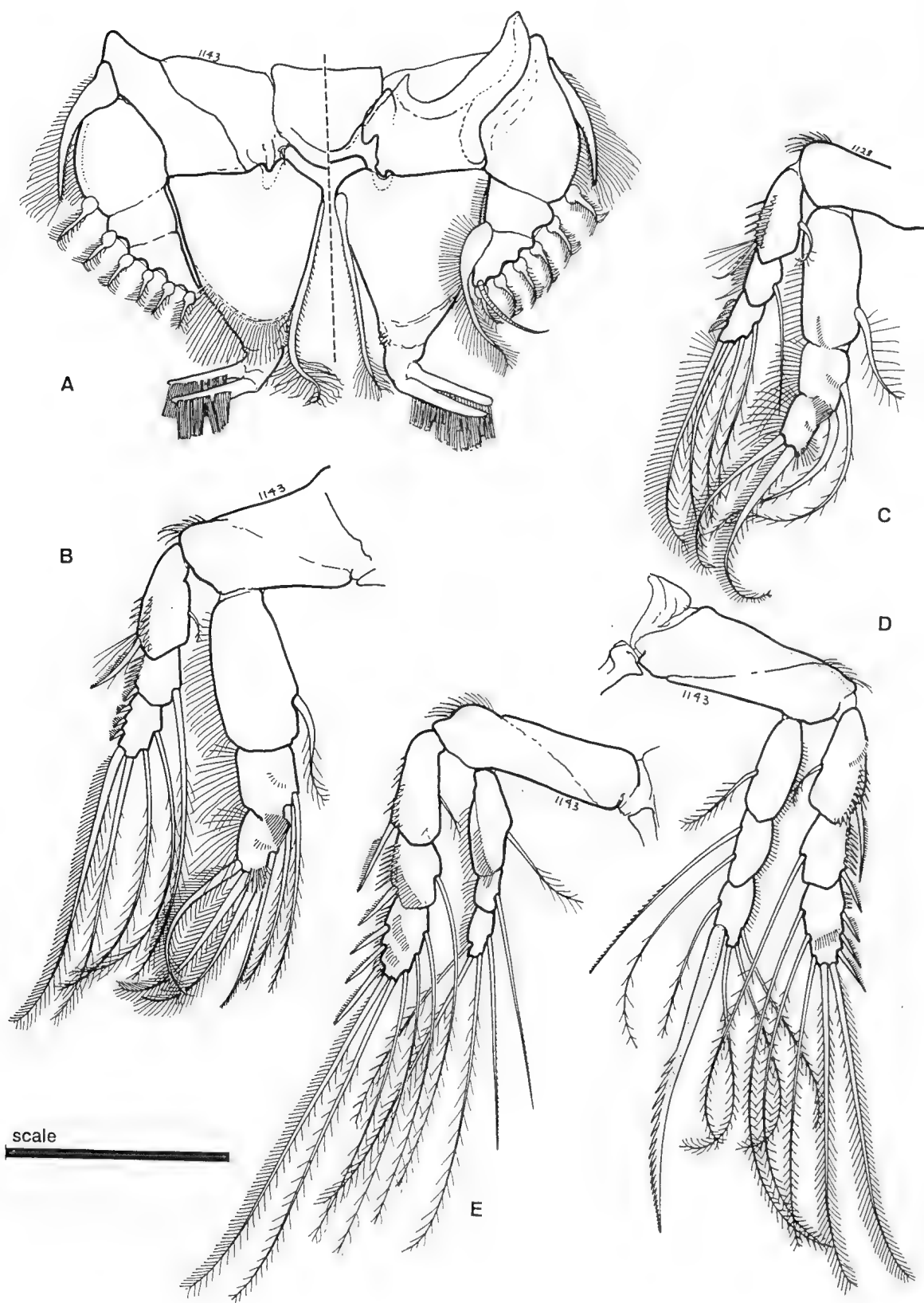


Fig. 10. *Porcellidium ocellum*. A – P1, anterior – left, posterior – right; B – female P2; C – male P2; D – P3; E – P4. Scale bar: A-E = 0.1 mm.

mm, ratio of body width to rostrum 3.6. Urosome width to length ratio 1.54. Caudal ramus length to width ratio 1.6.

**Males.** Mean length 0.56 mm (SD = 0.012, N = 7), Cephalosome length 0.32 mm, width 0.38 mm, body length to width ratio 1.47.

**Adult female** (Fig. 7A). Anterior outline of cephalosome semicircular. Rostrum prominent, anterior almost straight with narrow hyaline edge (Fig. 9G). Hyaline border of cephalosome and epimeral lobes 6–7  $\mu$ m wide. Dorsal surface inconspicuously pitted.

Urosome broad, fringed with marginal setules (Fig. 8A), sides of anterior lobe straight or slightly concave, posterior lobe rounded, medial corner not rounded, conspicuous lateral notch between anterior and posterior lobes. Caudal arch deep, one-third of urosome length.

Caudal ramus rectangular (Fig. 8D), medial edge slightly convex giving rami a divergent appearance, medial edge bordered with fine setules, similar setules on external edge towards extremity, external corner emarginate.  $\alpha$  seta about quarter of the way down ramus,  $\beta$  midway between  $\alpha$  and  $\gamma$ , terminal seta 1 pinnate, setae 2 and 3 plain, closely set, seta 4 at medial corner, pinnate, terminal fringe of fine setules present.

Limbs with typical setation. Antenna (Fig. 8H), spatulate claw on endopod finely serrulate, terminal portion of geniculate setae plain. Mandibles without patch of setules on anterior lobe, first pilose seta on palp large, swollen. Maxillule (Fig. 9B) and maxilla (Fig. 9E) similar to *P. hormosirii*. Rounded medial lobe of coxa and basis of maxilliped with fimbriate border, fimbriate process on basis (Fig. 9D). First pereopod (P1, Fig. 10A) with single crescent of fine denticulate pegs on article 1 of exopod, peg fields absent from proximal article of endopod. P2 and P4 as shown in Figure 10B,E. Sabre-like spinous seta on article 3 of P3 endopod (Fig. 10D) longer than endopod (1.3:1). Distal article of P5 (Fig. 8B,C) broadly lanceolate, apex pointed, does not reach beyond middle of posterior lobe of urosome.

**Adult male** (Fig. 7B). Anterior outline of cephalosome a truncated ellipse, obtusely pointed in midline; lateral angle of antennule socket prominent (Fig. 9F), with low 'epaulet' to rounded shoulder. Hyaline border and dorsal pits as for female.

Urosome (Fig. 8G), anterior lobe rounded, posterior lobe with two apical setules, caudal arch very shallow. Caudal ramus quadrate, setation as for female (Fig. 8E).

Antennule typically modified (Fig. 9A). Proximal, middle and distal coupling denticles flat, folded with serrate distal edge, middle denticle large with associated plumose seta. Ventral blade present plus large anterior blade-like spine about half length of ventral blade, small conical peg at base of spine. Terminal segments nearly as long as compound segment.

Mandible (Fig. 9C) with first pilose seta on palp slender. First pereopod (P1), P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig.

10C). Terminal setae of P5 lanceolate with pinnate lateral border (Fig. 8F).

**Remarks.** The trivial name, *ocellum*, refers to a conspicuous red spot behind the rostrum which gives the appearance of a cyclopean eye (*L. ocellus* = a little eye). The body is almost transparent with a slight amber tint. A dorsal red patch of variable intensity appears on metasomal segments 1 and 2. Skeletal structures supporting the rostrum and antennules are red giving the characteristic 'eye-spot' (Fig. 7A,B).

Spirit specimens lose their colour and might be confused with *P. hormosirii* as they are about the same size. *Porcellidium ocellum* is easily distinguished by the male's rounded shoulders and prominent antennular socket and the urosome of the female which has a distinct notch but no scar between anterior and posterior lobes. The caudal rami are slightly divergent with the alpha seta slender (see Figs 9F; 8A,D).

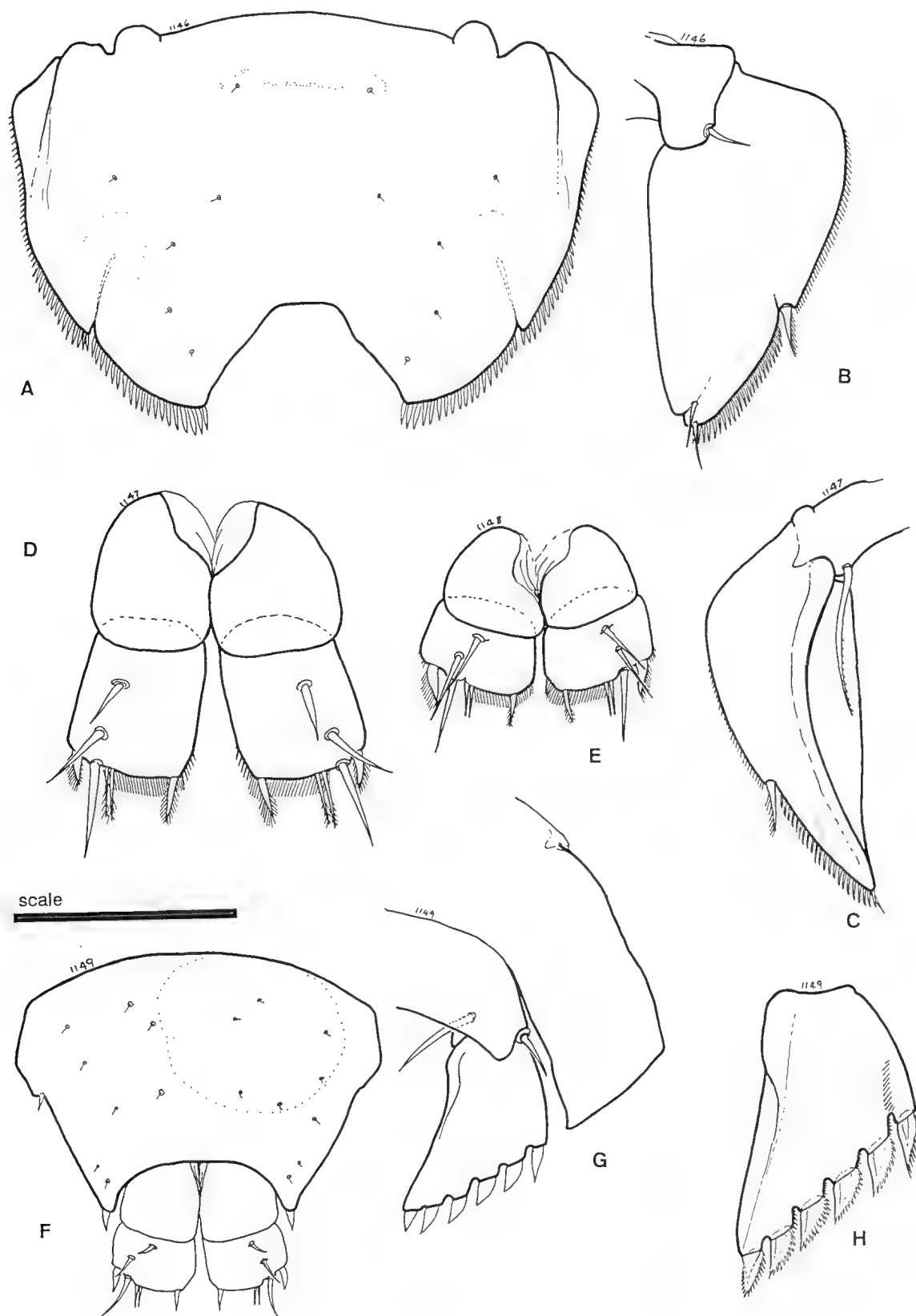
**Distribution and abundance.** *Porcellidium ocellum* is a southern species; it is common at Broulee and Twofold Bay, but has not been recorded north of Batemans Bay. Next to *P. hormosirii* it is the most abundant species on the south coast. Population densities of over 100 per plant are frequently encountered on *Ecklonia radiata*. Occasionally small numbers are found on *Phyllospora*, *Caulerpa*, *Cystophora*, *Sargassum*, and on encrusted stones in the infralittoral fringe and sublittoral zone.

### *Porcellidium pulchrum* n.sp.

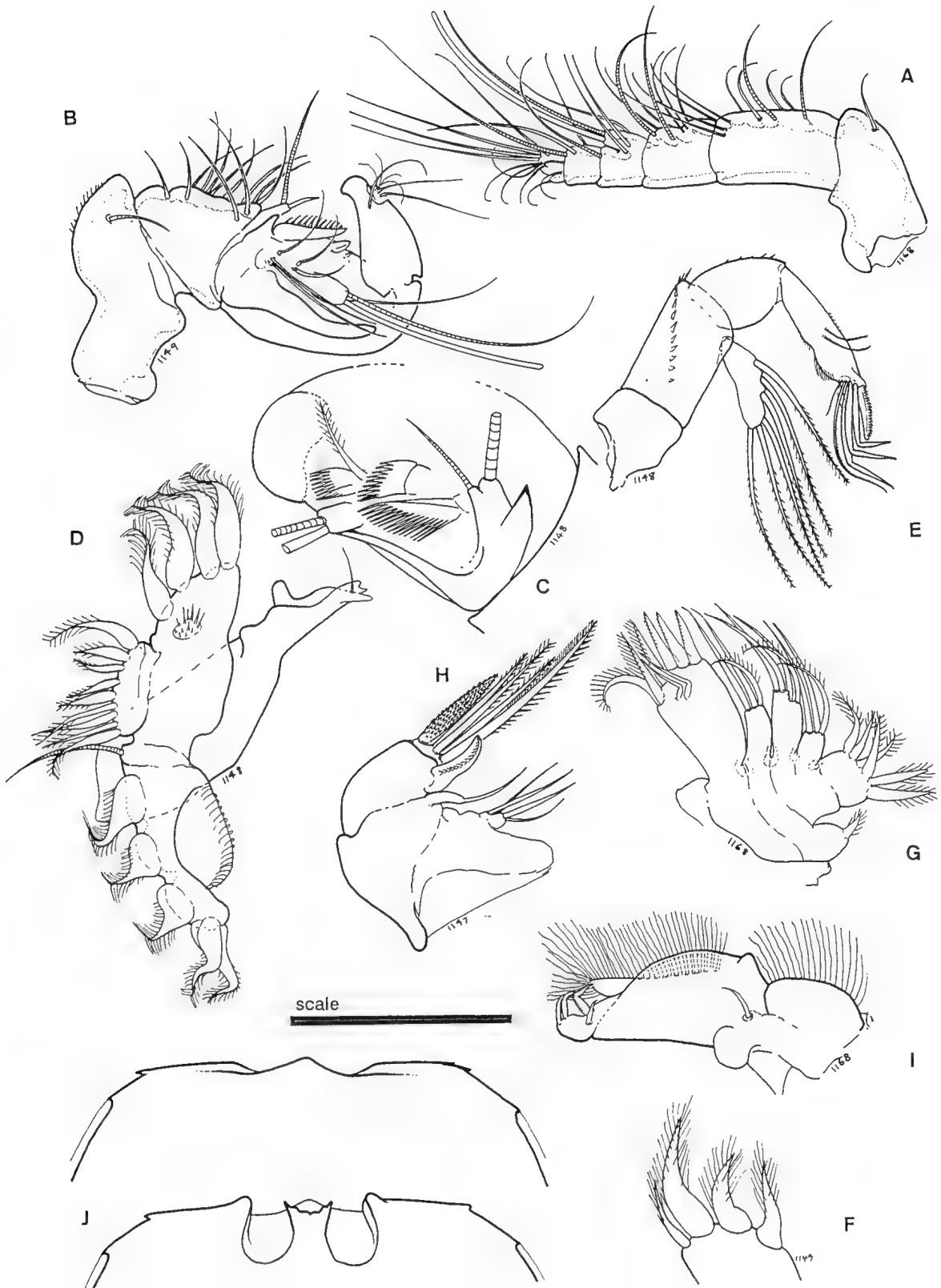
Figs 7, 11–13

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35442; ALLOTYPE adult male, AM P35443; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35444; 4 female + 4 male paratypes [Br 82] BM(NH) 1992.418–425, (other material [Br15] BM(NH) 1992.426–435. Dissections from which illustrations were made have been designated paratype material (slides 1146, 1147 female, 1148 male); these and remaining type population held at ZANU, registration Po.RR.[Br.82] [total type population 146 females (66 carrying eggs), 116 males (28 coupled to juvenile females)]. Taken from *Ecklonia radiata* in the infralittoral fringe at edge of Broulee rock platform, Broulee, NSW (35°52'S 150°11'E), 14 Sept. 1982, V.A.P. Harris.

**Diagnosis.** *Adult female.* Typically lemon yellow with broad red stripe down back; mean length 0.71 mm, rostrum width 0.13 mm, ratio of cephalosome width to rostrum 3.6; dorsal surface inconspicuously pitted; urosome broad, almost semicircular, medial corners not rounded, slight lateral notch and scar; caudal rami rectangular, medial corner not bevelled, lateral corner not emarginate, setae 1 and 4 pinnate, seta 4 set at medial corner,  $\alpha$  seta about halfway down ramus,  $\beta$  close to posterior border; peg field on first article of P1 endopod



**Fig. 11.** *Porcellidium pulchrum*. A – female urosome; B,C – female P5 (dorsal and ventral); D – female caudal ramus; E – male caudal ramus; F – male urosome; G – male P5 plus third and fourth epimeral lobes; H – male P5. Scale bar: A,B,C,F,G = 0.1 mm; D,E,H = 0.065 mm.



**Fig. 12.** *Porcellidium pulchrum*. A – female antennule; B – male antennule, showing long ventral blade; C – coupling denticles; D – female mandible; E – antenna; F – male mandibular palp; G – maxillule; H – maxilla; I – maxilliped; J – anterior edge of male cephalosome (dorsal and ventral focus). Scale bar: A,B,D,E,F,H,I = 0.075 mm; C,G = 0.045 mm; J = 0.165 mm.

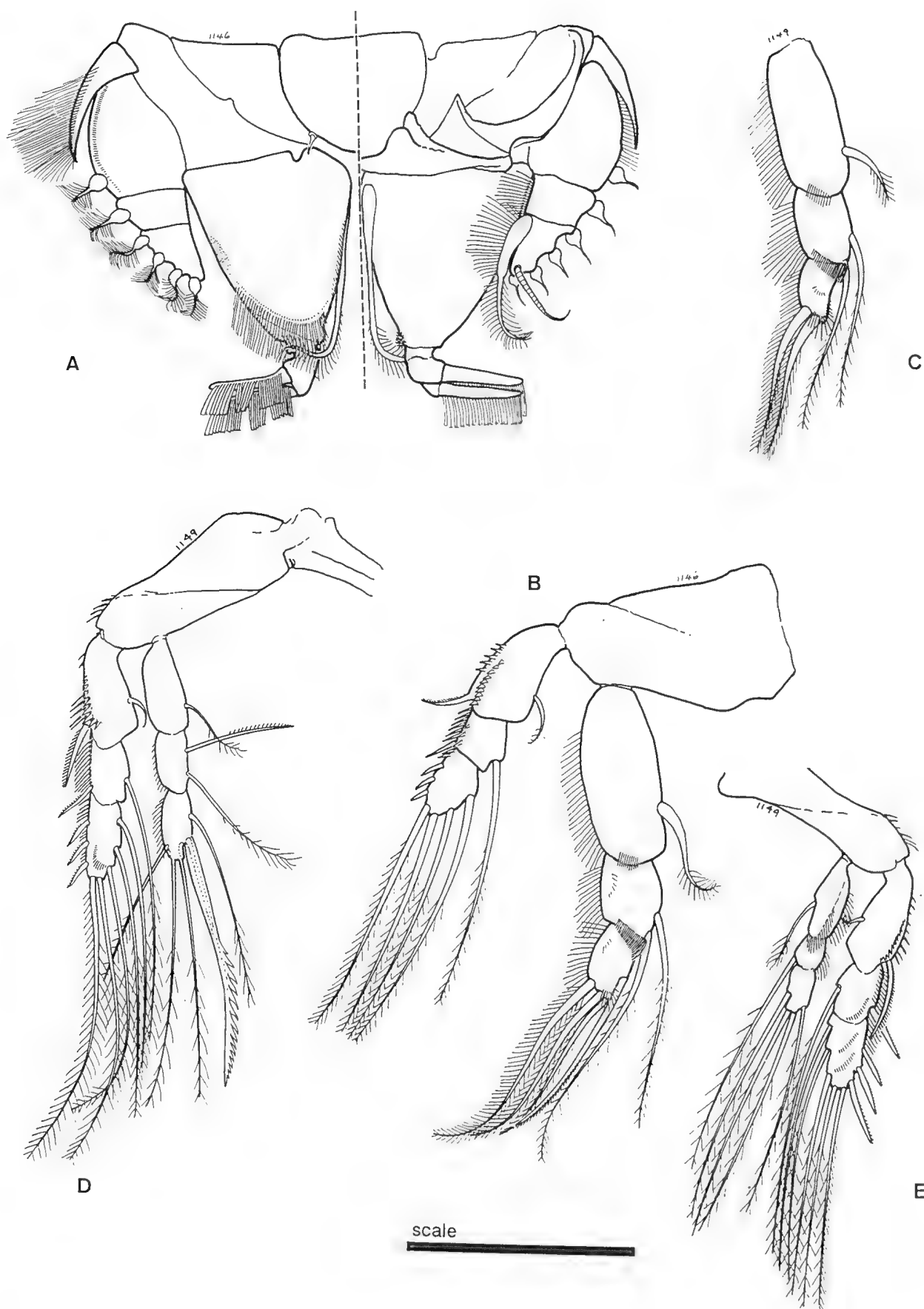


Fig. 13. *Porcellidium pulchrum*. A – P1, anterior - left, posterior - right; B – female P2; C – male P2 endopod; D – P3; E – P4. Scale bar: A-E = 0.1 mm.



very small or absent; apex of P5 not pointed.

**Adult male.** Lateral corner of antennule socket conspicuous, shoulders rounded; antennule with prominent ventral blade.

**Dimensions. Females.** Mean length 0.71 mm (SD = 0.028, N = 17), cephalosome length 0.4 mm, width 0.47 mm (SD = 0.017), height 0.11 mm, body length to width ratio 1.5. Rostrum 0.13 mm wide, ratio of body width to rostrum 3.6. Urosome width to length ratio 1.5. Caudal ramus length to width ratio 1.2.

**Males.** Mean length 0.55 mm (SD = 0.018, N = 20), Cephalosome length 0.31 mm, width 0.39 mm, body length to width ratio 1.4.

**Adult female** (Fig. 7C). Anterior outline of cephalosome semicircular. Rostrum slightly convex with hyaline edge; projects about one-quarter of width. Hyaline border of cephalosome and epimeral lobes 5  $\mu$ m wide. Indistinct shallow pits (2  $\mu$ m in diameter) cover dorsal surface, occasional sensory setules present.

Urosome broad, semicircular (Fig. 11A), edge of anterior lobe with fine setules anteriorly and larger setules posteriorly, laterodorsal ridge, posterior lobe curved, fringed with larger setules, medial corners not rounded; slight lateral notch and scar between anterior and posterior lobes. Caudal arch one-quarter length of urosome.

Caudal ramus almost quadrate (Fig. 11D), medial edge straight, lateral corner not emarginate.  $\alpha$  seta short, located about halfway down ramus,  $\beta$  seta halfway between  $\alpha$  and  $\gamma$ , terminal setae pinnate, 2 and 3 slender and set close together, 4 at medial corner, terminal fringe of very fine oblique setules. In their natural position the rami do not project beyond urosome.

Limbs with typical setation. Antenna (Fig. 12E), terminal portion of geniculate setae on endopod plain, spatulate claw with serrulate border. Mandible (Fig. 12D) with patch of setules on anterior lobe. Maxillule (Fig. 12G) and maxilla (Fig. 12H) similar to *P. hormosirii*. Maxilliped (Fig. 12I) with rounded medial coxal lobe, fimbriate border to coxa and basis, fimbriate process on basis. First pereopod (P1) endopod with peg field at lateral end of fimbriate crescent very small or absent (Fig. 13A). P2 and P4 as shown in Figure 13B,E. Sabre-like spinous seta on endopod of P3 slightly longer (1.2:1) than endopod (Fig. 13D). Distal article of P5 ovate, apex not pointed; reaches lateral notch of urosome (Fig. 11B,C).

**Adult male** (Fig. 7B). Anterior outline of cephalosome a truncated ellipse, convex in midline, lateral angle to antennule socket not prominent, shoulders rounded (Fig. 12J). Hyaline border and dorsal pits as in female.

Urosome (Fig. 11F) with stout setule at apex of posterior lobe.

Caudal ramus quadrate (Fig. 11E), setation as for female.

Antennule (Fig. 12B) typically modified. Proximal coupling denticle a long triangular pectinate comb,

medial and distal denticles thin plates with serrate edge (Fig. 12C). Ventral blade present, narrow, almost as long as compound segment, anterior spine present. Terminal segment half length of compound segment.

Mandible with first pilose seta on palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 13C). Terminal setae of P5 all similar, flat triangular with serrated lateral edge (Fig. 11H).

**Remarks.** The trivial name refers to the colour of living animals (*L. pulcher* = beautiful). This is lemon yellow with a broad red stripe down the middle of the back, however, a small proportion of animals taken from Twofold Bay, Eden, lack the red stripe or it is broken into a series of red dots. No other morphological differences have been noticed between these two colour forms.

Living specimens of *Porcellidium pulchrum* could be confused with *Acutiramus rufolineatus* which has a dorsal red stripe, but their size and other differences listed under *A. rufolineatus* (see below) readily distinguish them. Populations of *P. pulchrum* have been found only on *Ecklonia radiata*, although occasionally isolated individuals have been found on *Phyllospora* and *Sargassum*.

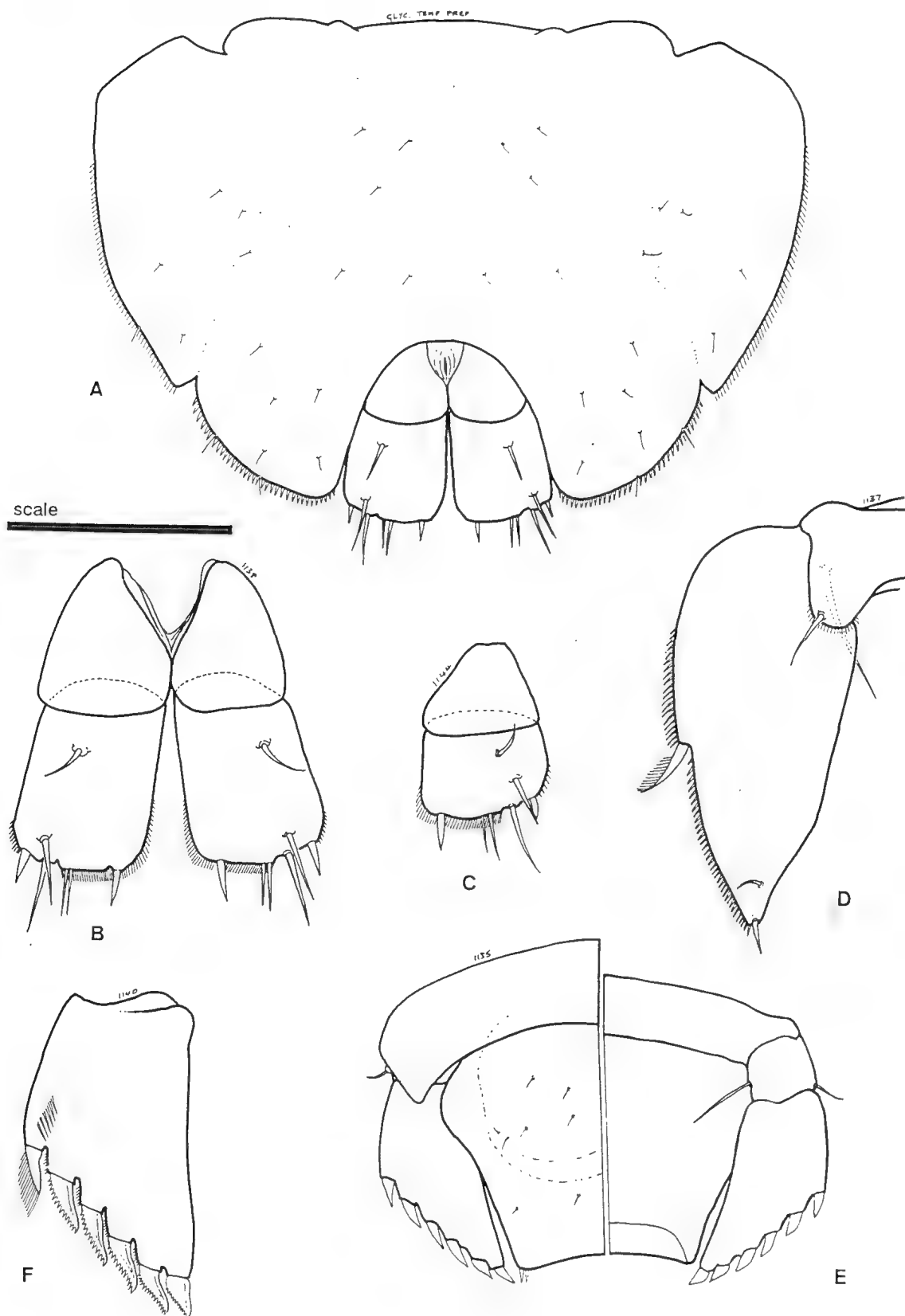
**Distribution and abundance.** This species has been recorded only from Kioloa, Broulee and Twofold Bay stations. Large populations (greater than 100) are sometimes encountered. On *Ecklonia* it is second in abundance to *P. ocellum* with which it is invariably associated.

### *Porcellidium erythrogastrum* n.sp.

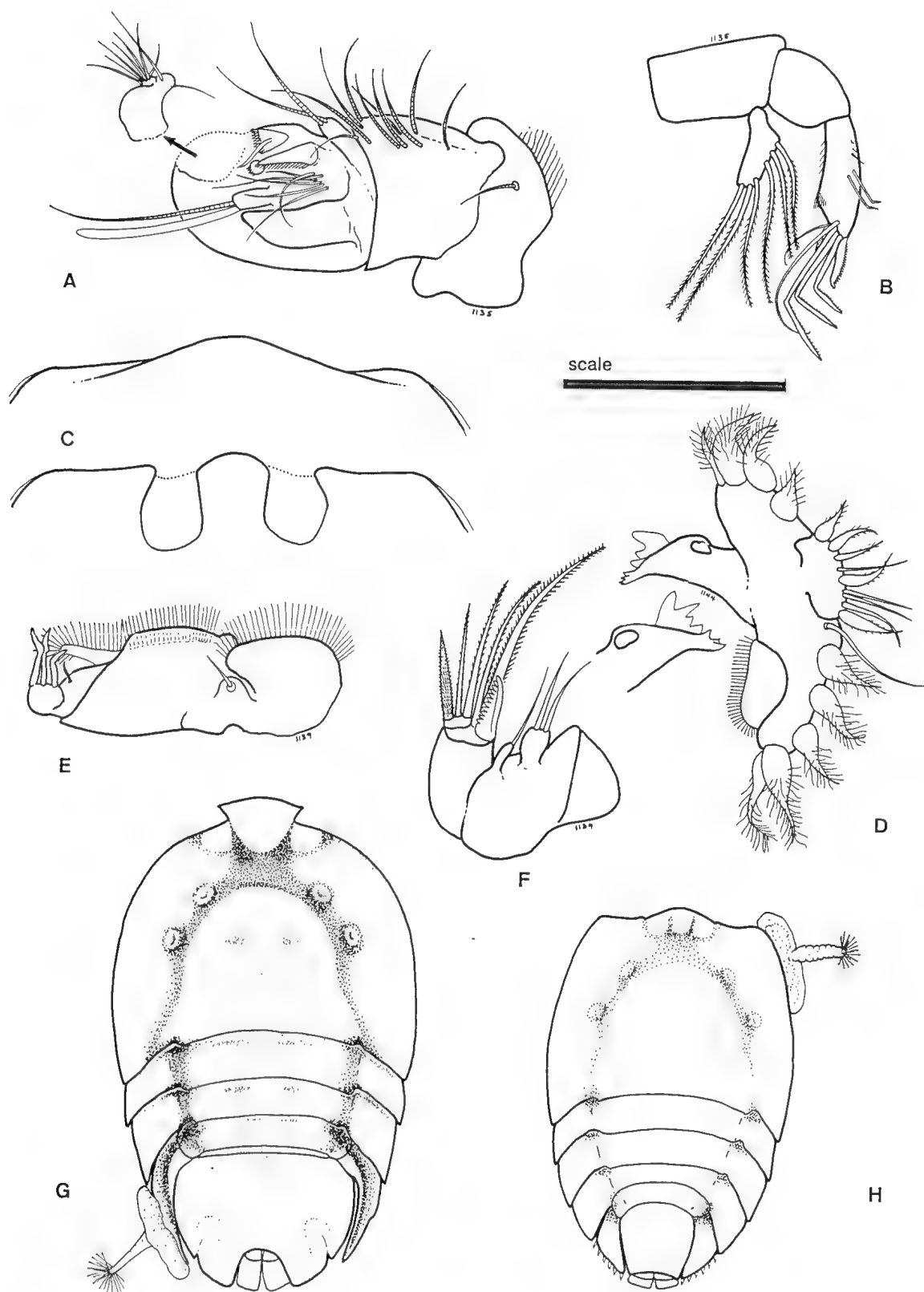
Figs 14-16

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35439; ALLOTYPE adult male, AM P35440; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35441; 4 female and 3 male paratypes [Mb 6] BM(NH) 1992.436-442, (other material [Ki21] BM(NH) 1992.443-452. Dissections from which illustrations were made have been designated paratype material (slides 1138 female, 1135, 1144 male); these and remaining type population material held at ZANU, registration Po.I.[Mm.6] [total type population 208 females (158 carrying eggs), 125 males (42 coupled to juvenile females)]. Taken from *Phyllospora comosa* in the infralittoral fringe at Mullamarang Reef, Kioloa, NSW (35°33'S 150°23'E), 3 Nov. 1975, V.A.P. Harris.

**Diagnosis. Adult female.** Almost colourless with ventral internal edge of cephalosome red; mean length 0.83 mm, rostrum width 0.14 mm, ratio of cephalosome width to rostrum 3.7; dorsal surface smooth, no pits; urosome broad with lateral notch and scar, medial corners rounded; caudal rami rectangular, slightly emarginate,  $\beta$  seta near posterior border, terminal setae



**Fig. 14.** *Porcellidium erythrogastrum*. A – female urosome; B – female caudal rami; C – male caudal ramus; D – female P5; E – male urosome (dorsal and ventral); F – male P5. Scale bar: A,D,E = 0.1 mm; B,C,F = 0.065 mm.



**Fig. 15.** *Porcellidium erythrogastrum*. A – male antennule, terminal segment displaced to show coupling denticles; B – antenna; C – anterior edge of male cephalosome (dorsal and ventral focus); D – male mandible and incisor process; E – maxilliped; F – maxilla; G – adult female, stippling indicates red colouration. A suctorian, *Ophryodendron*, is shown attached to P5; H – adult male with suctorian attached. Scale bar: A,E,F = 0.075 mm; B,D = 0.1 mm; C = 0.165 mm; G,H = 0.38 mm.

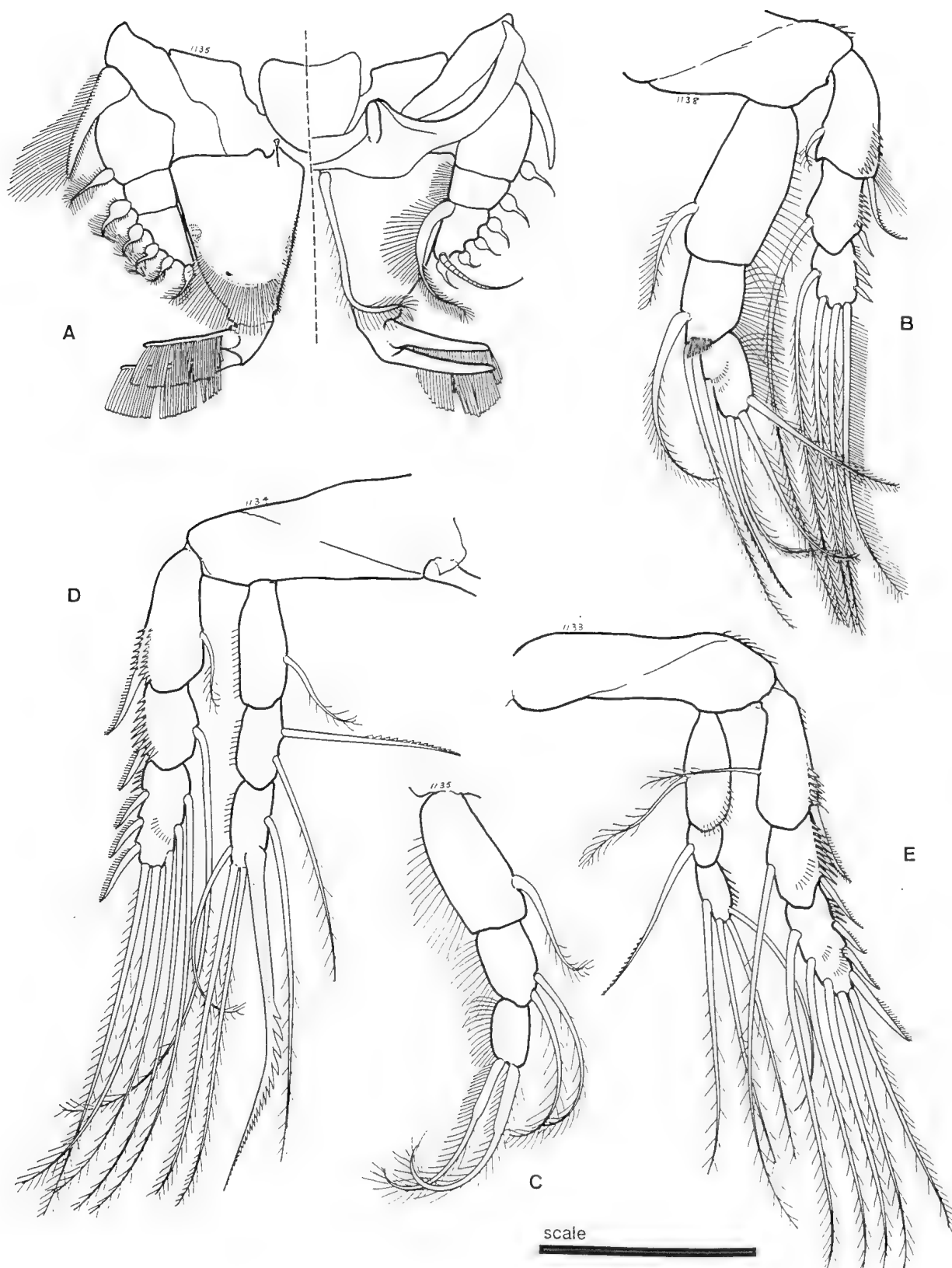


Fig. 16. *Porcellidium erythrogastrum*. A – P1, anterior – left, posterior – right; B – female P2; C – male P2 endopod; D – P3; E – P4. Scale bar: A-E = 0.1 mm.

plain; small lateral peg field on endopod of P1; apex of P5 pointed.

**Adult male.** Corner of antennule socket obscured, shoulders rounded; antennule with ventral blade.

**Dimensions. Females.** Mean length 0.83 mm (SD = 0.022, N = 12), cephalosome length 0.47 mm, width 0.52 mm (SD = 0.015), height 0.11 mm, body length to width ratio 1.6. Rostrum 0.14 mm wide, projects about 0.05 mm, ratio of body width to rostrum 3.7. Urosome width to length ratio 1.5. Caudal ramus length to width ratio 1.45.

**Males.** Mean length 0.61 mm (SD = 0.011, N = 8), cephalosome length 0.36 mm, width 0.41 mm (SD = 0.007), body length to width ratio 1.45.

**Adult female** (Fig. 15G). Anterior outline of cephalosome semicircular. Rostrum prominent, anterior slightly convex with hyaline edge. Hyaline border of cephalosome and epimeral lobes 5–8  $\mu$ m wide. Dorsal surface of body and urosome smooth, without pits, numerous collared setae present arranged in characteristic pattern.

Urosome broad, semicircular (Fig. 14A), bordered with marginal setules, deep lateral notch and conspicuous scar between anterior and posterior lobes, both lobes convex, medial corners rounded. Caudal arch deep, one-third urosome length.

Caudal ramus rectangular (Fig. 14B), rounded at medial corner, slightly emarginate at lateral corner. Alpha seta about one-third of way down ramus,  $\beta$  seta near posterior border, terminal setae plain, 4 set in slightly, 2 and 3 slender set close together, terminal fringe of very fine setules present.

Limbs with typical setation. Antenna (Fig. 15B) with spatulate claw of endopod strongly serrated, geniculate setae with finely serrulate terminal portion. Mandible with first pilose seta on palp large, swollen. Maxillule as for *P. ocellum*, maxilla as shown in Figure 15F. Maxilliped (Fig. 15E) with rounded medial coxal lobe, coxa and basis with fimbriate edge, fimbriate process on basis. First pereopod (P1, Fig. 16A) with fine setules along medial edge of article 1 of endopod, small pear shaped denticulate peg field at lateral end of fimbriate crescent. P2 and P4 as shown in Figure 16B,E. Sabre-like spinous seta on article 3 of P3 endopod (Fig. 16D) slightly longer than endopod (1.2:1). Distal end of P5 basis with fringe of setules near dorsal seta (Fig. 14D), ventral seta plain, distal article broadly lanceolate, apex pointed, barely reaching lateral notch of urosome.

**Adult male** (Fig. 15H). Anterior outline of cephalosome a truncated ellipse, slightly convex in midline, lateral angle of antennule socket obscured, shoulders rounded (Fig. 15C). Hyaline border and smooth surface as for female.

Urosome (Fig. 14E) with boundary between anterior and posterior lobes indistinct, no dorsolateral seta.

Caudal rami quadrate (Fig. 14C), setation as for female.

Antennule (Fig. 15A) typically modified. Proximal coupling denticle long, triangular with finely pectinate edge, medial denticle serrulate distally, associated with plumose seta, distal denticle very small. Ventral blade present about half length of compound segment. Terminal segment short (less than quarter length of compound segment).

Mandible (Fig. 15D) with first pilose seta on palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 16C). First terminal seta of P5 unipinnate, remainder with serrulate lateral edge (Fig. 14F).

**Remarks.** The trivial name *erythrogastrum* refers to the red ventral (sternal) border of the cephalosome (G. *erythros* = red + *gastra* = belly).

The ventral internal edge of the cephalosome, trabeculae, apodemes at the base of the limbs and falciform ventral ridge of P5 is red, the rest of the body is opalescent white or colourless. Spirit specimens lose their colour, but may be distinguished from other species by their size, semicircular urosome with deep lateral notch and prominent scar, and the position of the beta seta on the caudal ramus (Fig. 14A,B).

*Porcellidium erythrogastrum* is commonly parasitised by an epizoic suctorian, *Ophryodendron* (Fig. 15G,H), which attaches to the edge of the cephalosome or, more usually, the fifth limb (P5). The association between copepod and protozoan appears to be specific for this suctorian is never found on other species of *Porcellidium* living on the same piece of seaweed.

As many as six of these protozoans have been found on the same individual, but one or two is more usual. A marked disparity has been noted between the sexes; female copepods have a higher percentage parasitism than males (Table 1, Appendix). The type population has an incidence of 7% parasitism, although most populations have a much higher figure (51% has been recorded in one population).

**Distribution and abundance.** This species has only been recorded from the Broulee and Kioloa stations. Large populations (100+) have been found on *Phyllospora comosa* and *Cystophora* sp. Isolated individuals are occasionally found on *Ecklonia*, *Sargassum* and *Colpomenia*.

### 'Naviculum' subgroup

#### *Porcellidium naviculum* n.sp.

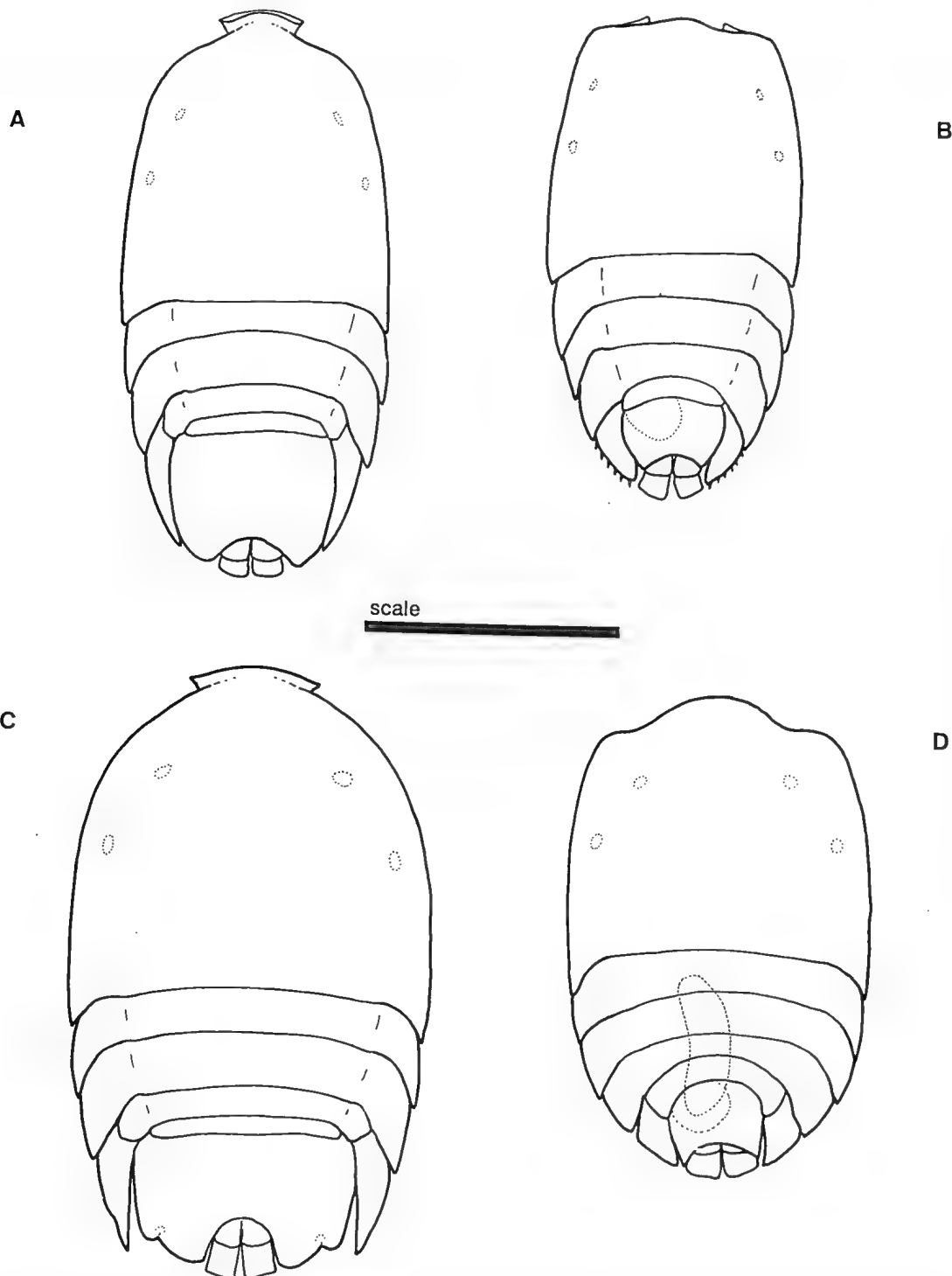
Figs 17-19

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35454; ALLOTYPE adult male, AM P35455; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35456; 4 female and 3 male paratypes [Mb.6] BM(NH) 1992.453-459, (other material [Br46,58] BM(NH) 1992.460-469). Dissections from which illustrations were made have been designated paratype material

(slides 1238 female, 1239 male); these and remaining type population material held at ZANU, registration Po.T.[Mb.6] [total type population 44 females (34 carrying eggs), 36 males (8 coupled to juvenile females)]. Taken from *Cystophora* sp., in the infralittoral fringe, Merimbula Headland, Merimbula, NSW (36°53'S 149°56'E), 2 Dec. 1982, V.A.P. Harris.

**Diagnosis.** *Adult female.* Amber yellow; mean length

0.72 mm, body narrow (length/width ratio greater than 2); rostrum width 0.1 mm, ratio of cephalosome width to rostrum 3.3; dorsal surface inconspicuously pitted; urosome narrow, U-shaped in outline, anterior and posterior lobes indistinct, no notch; caudal rami rectangular, slightly emarginate, medial corner rounded with terminal seta 4 set in,  $\beta$  seta close to  $\gamma$ ; peg field down medial border of P1 endopod, larger peg field



**Fig. 17.** *Porcellidium naviculum*: A – adult female, dorsal view; B – adult male, dorsal view. *Porcellidium phyllosporum*: C – adult female, dorsal view; D – adult male, dorsal view. Scale bar: A,B = 0.315 mm; C,D = 0.4 mm.

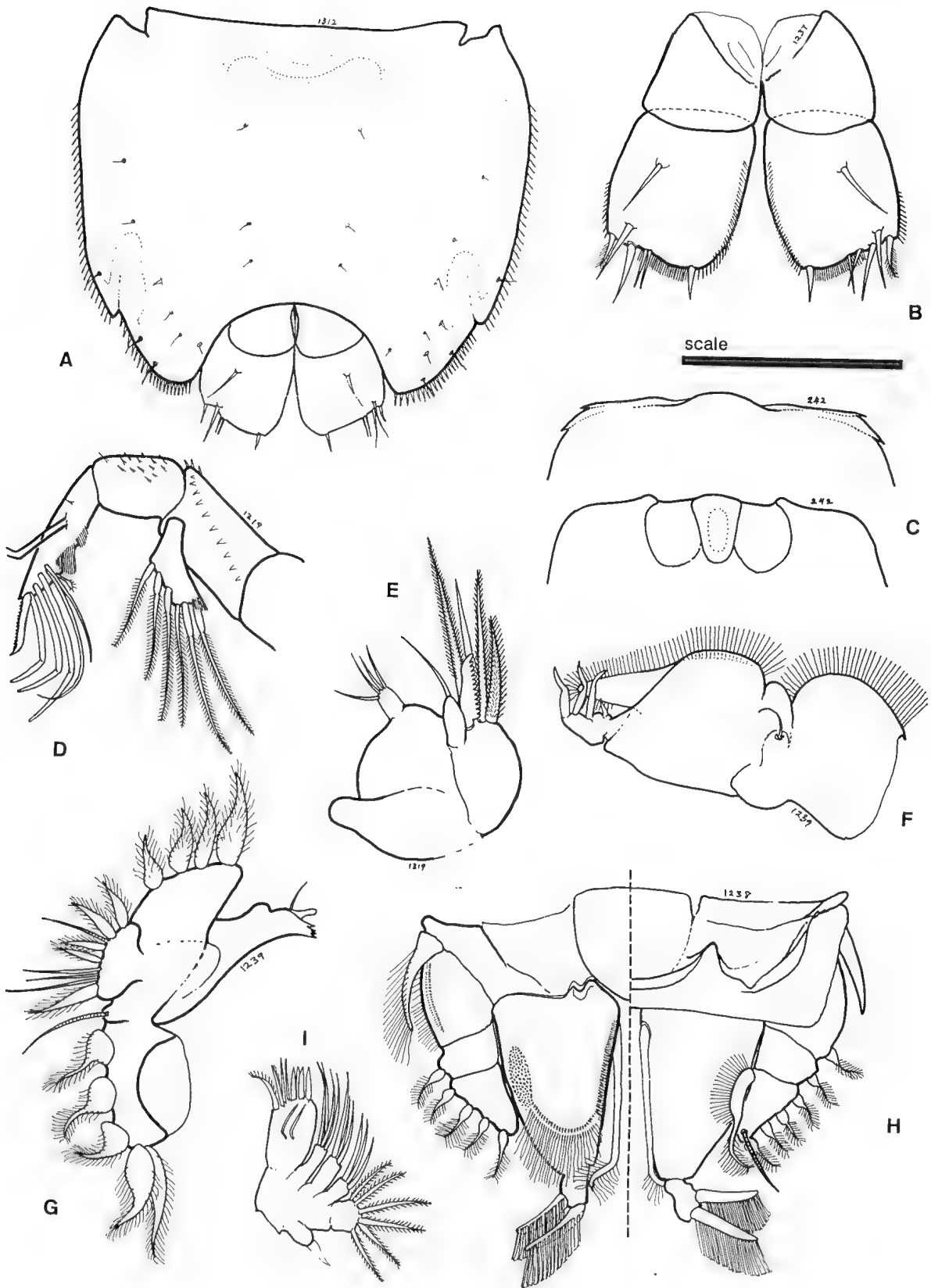
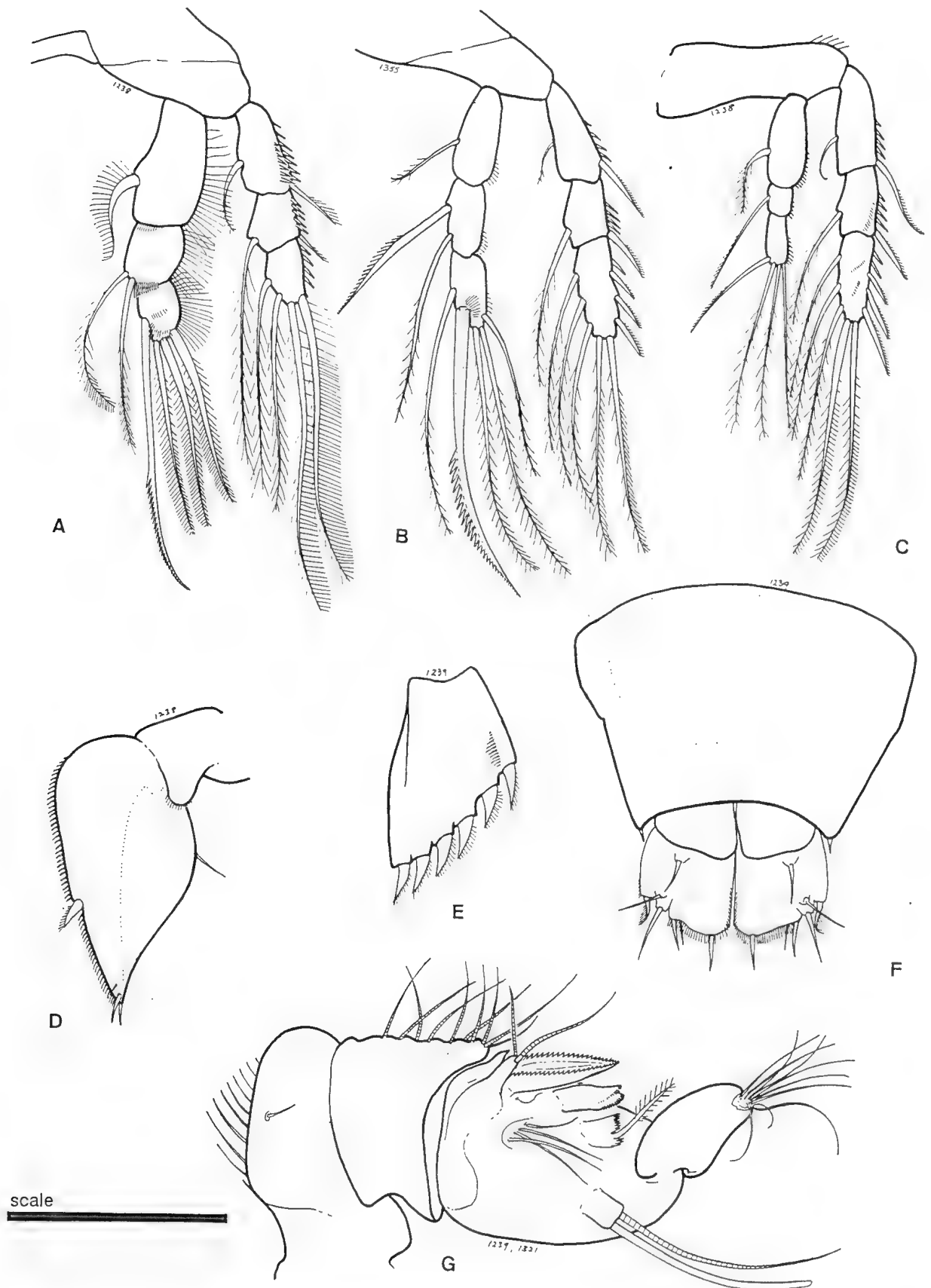


Fig. 18. *Porcellidium naviculum*. A – female urosome; B – female caudal rami; C – anterior edge of male cephalosome (dorsal and ventral focus); D – antenna; E – maxilla; F – maxilliped; G – female mandible; H – P1, anterior - left, posterior - right; I – maxillule. Scale bar: A = 0.1 mm; B,D = 0.065 mm; C = 0.165 mm; E,F,I = 0.05 mm; G,H = 0.075 mm.





**Fig. 19.** *Porcellidium naviculum*. A – female P2; B – P3; C – P4; D – female P5; E – male P5; F – male urosome and caudal rami; G – male antennule showing coupling denticles. Scale bar: A,B,C,E,F = 0.1 mm; D = 0.125 mm; G = 0.06 mm.

laterally; P5 apex pointed.

**Adult male.** Antennule socket obscured, shoulders rounded; no ventral blade on antennule.

**Dimensions. Females.** Mean length 0.72 mm (SD = 0.019, N = 12), cephalosome length 0.37 mm, width 0.33 mm (SD = 0.017), height 0.22 mm, body length to width ratio 2.18. Rostrum 0.1 mm wide, ratio of body width to rostrum 3.3. Urosome width to length ratio 1.2. Caudal ramus length to width ratio 1.3.

**Males.** Mean length 0.57 mm (N = 7), cephalosome length 0.31 mm, width 0.30 mm, height 0.18 mm, body length to width ratio 1.9.

**Adult female** (Fig. 17A). Body outline an elongate ellipse, lacks typical dorsoventral flattening of other *Porcellidium* species. Rostrum projects about one-third its width, anterior edge slightly bowed with acute corners and hyaline border. Hyaline border of cephalosome 6  $\mu$ m wide. Dorsal surface finely pitted (pits 2  $\mu$ m in diameter).

Urosome narrow (Fig. 18A), together with caudal rami it gives a smooth semicircular posterior outline, anterior lobe long, slight indentation marks boundary with posterior lobe which is short, bordered with setules, medial corner rounded. Caudal arch about one-fifth length of urosome.

Caudal ramus (Fig. 18B) short rectangular with setules on medial and lateral edges, slightly emarginate, medial corner rounded with seta 4 set in from corner.  $\alpha$  seta one-third way down ramus,  $\beta$  seta close to  $\gamma$ , terminal seta 1 pinnate, 2 and 3 fine, close together, terminal fringe of very fine setules present.

Limbs with typical setation. Antenna endopod with serrulate spatulate claw, geniculate setae plain (Fig. 18D). Mandible as shown in Figure 18G. Maxillule (Fig. 18I) and maxilla (Fig. 18E) similar to *P. hormosirii*. Maxilliped (Fig. 18F) with rounded medial coxal lobe, coxa and basis with fimbriate edge, fimbriate process on basis. First pereopod (Fig. 18H) with crescentic double row of pegs on article 1 of exopod; endopod with denticulate peg field along medial border and oval peg field at lateral extremity of fimbriate crescent. P2 (Fig. 19A) with unusually long serrulate spinous internal seta on distal article of endopod (seta:endopod ratio = 1.2:1). Sabre-like spinous seta of P3 (Fig. 19B) slightly longer than endopod (1.2:1). P4 as shown in Figure 19C. Distal article of P5 broadly lanceolate or ovate with one terminal and 2 dorsal setae at its extremity (Fig. 19D); P5 does not extend beyond anterior lobe of urosome.

**Adult male** (Fig. 17B). Anterior outline strongly truncated with tightly rounded shoulders, slightly convex in midline, lateral angle of antennule socket not visible from above (Fig. 18C). Hyaline border and dorsal pits as for female.

Urosome (Fig. 19F) with no division between anterior and posterior lobes or seta on anterior lobe, apical setule present.

Caudal rami quadrate (Fig. 19F), lateral corner emarginate, posterior border slightly oblique, setation similar to female.

Antennule typically modified (Fig. 19G). Proximal coupling denticle elongate triangle serrated along both edges, middle denticle tooth-like with double row of very fine serrations, distal denticle small with pectinate distal edge, associated with plumose seta. No ventral blade. Terminal segments about half length of compound segment.

First pilose seta on mandibular palp slender. P1, P3 and P4 as for female. Distal article of P2 endopod with 2 plumose setae. Terminal setae of P5 unipinnate.

**Remarks.** *Porcellidium naviculum* has been found only on *Cystophora*, particularly *C. moniliformis*. Its yellow brown colour closely matches this seaweed.

The body shape is unusual; when viewed from the side individuals resemble a small boat or gondola (*L. navicula* = a small boat). Females are more than twice as long as they are broad (l/w greater than 2), and their width is only about 1.5 times their height. In all other described species of *Porcellidium* the l/w ratio is less than 2 and body width is at least three and a half times height. It is possible that the narrow body is an adaptation to living on the narrow cylindrical thallus of *Cystophora*.

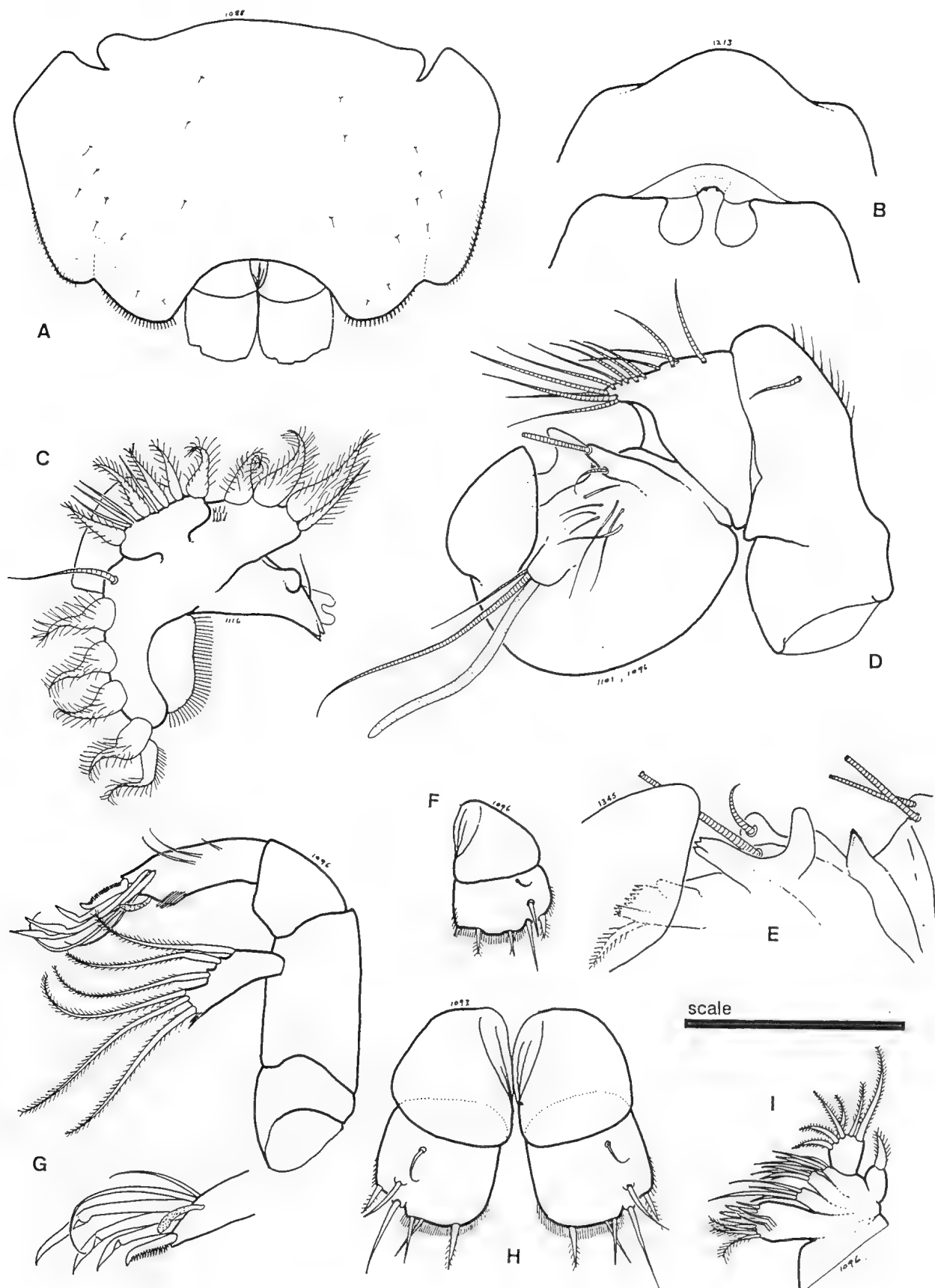
**Distribution and abundance.** This species has been recorded from Kioloa, Broulee and Merimbula, NSW. It is noticeably more abundant further south and must be regarded as a southern species.

### *Porcellidium phyllosporum* n.sp.

Figs 17, 20, 21

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35445; ALLOTYPE adult male, AM P35446; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35447; 3 females and 1 male paratypes [Tb.2] BM(NH) 1992.470-473 (other material [Br 10] BM(NH) 1992.474-483). Dissections from which illustrations were made have been designated paratype material (slides 1088, 1097 female, 1096 male); these and remaining type population held at ZANU, registration Po.P.[Tb.2] [total type population 28 females (6 carrying eggs), 14 males (6 coupled to juvenile females)]. Taken from *Phyllospora comosa* in the infralittoral fringe, Lookout Point, Twofold Bay, Eden, NSW (37°06'S 149°54'E), 3 Dec. 1982, V.A.P. Harris.

**Diagnosis. Adult female.** Orange-brown; mean length 0.93 mm, rostrum width 0.22 mm, ratio of cephalosome width to rostrum 2.6; dorsal surface inconspicuously pitted; urosome very broad, almost rectangular, posterior lobe short, concave notch and faint scar between anterior and posterior lobes, medial corner rounded; caudal rami quadrate, medial corner rounded with seta 4 set in from corner; peg fields on P1 endopod conspicuous (oval lateral field, broad field down medial



**Fig. 20.** *Porcellidium phylloporum*. A – male urosome; B – anterior edge of male cephalosome (dorsal and ventral focus); C – male mandible; D – male antennule (ventral), setae of terminal segment omitted; E – detail of coupling denticles (dorsal); F – male caudal ramus; G – antenna, inset - terminal setae; H – female caudal rami; I – maxillule. Scale bar: A = 0.2 mm; B = 0.3 mm; C,F = 0.125 mm; D,G,I = 0.09 mm; E = 0.055 mm; H = 0.1 mm.

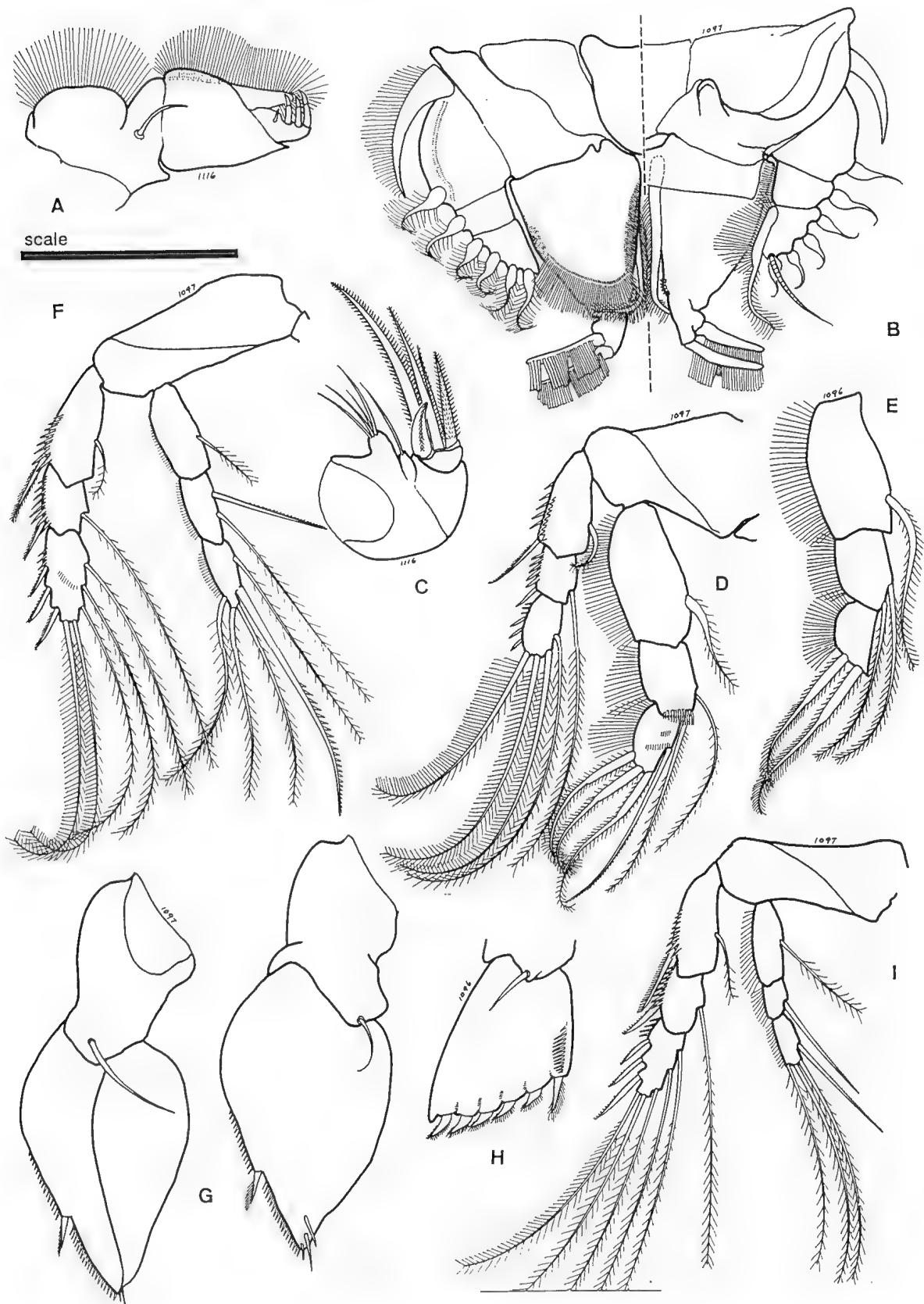


Fig. 21. *Porcellidium phyllosporum*. A – maxilliped; B – P1, anterior - left, posterior - right; C – maxilla; D – female P2; E – male P2 endopod; F – P3; G – female P5 (ventral and dorsal); H – male P5; I – P4. Scale bar: A,C = 0.09 mm; B,D,F,G,H,I = 0.165 mm; E = 0.125 mm.

edge); apex of P5 pointed.

**Adult male.** Cephalosome truncated, humped and bowed forward in mid-line to form deep overhang, antennal socket obscured, shoulders rounded; no ventral blade to antennule.

**Dimensions. Females.** Mean length 0.93 mm (SD = 0.024, N = 12), cephalosome length 0.6 mm, width 0.58 mm (SD = 0.016), height 0.15 mm, length to width ratio 1.6. Rostrum 0.22 mm wide, projects slightly, ratio of cephalosome width to rostrum 2.6. Urosome width to length ratio 1.7. Caudal ramus length to width ratio 1.1.

**Males.** Mean length 0.73 mm (N = 7), cephalosome length 0.45 mm, width 0.47 mm, ratio of length to width 1.55.

**Adult female** (Fig. 17C). Anterior of cephalosome hemi-elliptical, slightly humped in midline partly obscuring rostrum; antennule notch not visible from above. Rostrum very wide, anterior border curved with narrow hyaline edge, lateral corners acute. Hyaline border of cephalosome 8–11  $\mu$ m wide. Dorsal surface inconspicuously pitted, scattered sensory setae present.

Urosome short, very broad (almost rectangular, Fig. 20A), anterior lobe bordered with fine setules, rounded posteriorly, posterior lobe short, curved, bordered with stronger setules, rounded medial corner to caudal arch. Concave notch between anterior and posterior lobes. Caudal arch less than one-fifth of urosome length.

Caudal ramus very short, quadrate (Fig. 20H), medial corner rounded, lateral corner slightly emarginate with a few lateral setules.  $\alpha$  seta about halfway down ramus,  $\beta$  seta close to  $\gamma$ , terminal setae finely pinnate, 4 set in from medial corner, 2 and 3 set close together, terminal fringe of very fine setules present.

Limbs with typical setation. Antenna (Fig. 20G) with spatulate claw on endopod finely serrated, terminal portion of geniculate setae plain, articulate. Pars molaris of mandible short, solidly built, first pilose seta of palp large, swollen. Maxillule endites each with 4 setae (Fig. 20I). Maxilla as shown in Figure 21C. Maxilliped with rounded medial coxal lobe, coxa and basis with fimbriate border, fimbriate process to basis (Fig. 21A). First pereopod (P1, Fig. 21B) basis with prominent anteriolateral tubercle, double row of pegs on article 1 of exopod, article 1 of endopod with conspicuous denticulate peg field along medial border, oval peg field at lateral extremity of fimbriate crescent. P2 (Fig. 21D) with serrulate spinous internal seta on distal article of endopod. Sabre-like spinous seta on endopod of P3 (Fig. 21F) slightly longer than endopod (1.1:1). P4 as shown in Figure 21I. Distal article of P5 (Fig. 21G) short and broad (ovate when flat), apex pointed with terminal and 2 dorsal setae, does not reach beyond anterior lobe of urosome.

**Adult male** (Fig. 17D). Anterior outline of cephalosome a truncated ellipse with medial hump which extends forward as a conspicuous overhang obscuring the

antennule socket, shoulders rounded (Fig. 20B). Hyaline border and dorsal pits as for female.

Urosome with lateral seta to anterior lobe, caudal arch shallow.

Length of caudal ramus less than width, setation similar to female (Fig. 20F).

Antennule typically modified (Fig. 20D,E). Coupling denticles reduced, proximal denticle U-shaped with distal end tooth-like, distal denticle small with serrated border and plumose seta. No ventral blade but small anterior spine (Fig. 20E). Terminal segment broad, less than one third length of compound segment.

Mandible (Fig. 20C) with first pilose seta of palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 21E). First terminal seta on P5 longer than remainder, unipinnate (Fig. 21H).

**Remarks.** This species has been named after the seaweed, *Phyllospora*, upon which populations are commonly found. It is deep orange-brown in colour. It is easily distinguished by its large size, very broad rostrum, shape of urosome, quadrate caudal rami and peg fields on the endopod of P1.

**Distribution and abundance.** *Porcellidium phyllosporum* is a southern species. It is common at Broulee and Twofold Bay stations, and isolated individuals have been found at Kioloa, but it has not been recorded further north. Moderate sized populations (50+) have been found on *Phyllospora comosa* and smaller populations on encrusted stones in the sublittoral zone. Isolated individuals are occasionally found on *Ecklonia*, *Pterocladia*, *Colpomenia* and *Sargassum* in the sublittoral.

### *Acutiramus* n.gen.

**Diagnosis.** Anterior of female cephalosome semicircular, male truncated; hyaline border and dorsal pits present; urosome not very broad, epimeral expansions indistinctly divided into anterior and posterior lobes, posterior lobe narrow, pointed, caudal rami included in caudal arch of urosome; caudal rami rhomboidal with oblique posterior border, seta 4 at apex, setae 2 and 3 close together; maxillule endopod with 6 setae; maxilliped basis with fimbriate process, coxal lobe fimbriate; male P2 endopod with 2 plumose terminal setae; male P5 with 6 terminal setae; female P5 extends beyond caudal rami and may touch posteriorly.

**Females.** Cephalosome may be raised into an anteriomedial bulge above the rostrum. Rostrum narrow relative to cephalosome width (see w/R ratio in Table 4, Appendix).

Epimeral expansions of urosome not very broad, division into anterior and posterior lobes indistinct, region of posterior lobe narrow, triangular or pointed,

marginal setules present, caudal rami partly accommodated in caudal arch of urosome. Urosome width narrow relative to cephalosome (see urosome width/body width ratio in Table 4, Appendix).

Caudal rami rhomboidal with oblique posterior border, terminal seta 4 situated at apex.  $\beta$  seta may be close to  $\alpha$  or midway between  $\alpha$  and  $\gamma$ . Terminal setae 2 and 3 close together, slender and may lie parallel to the oblique posterior border so that they are difficult to see, seta 1 at lateral end of oblique border.

Maxillule endopod with 6 setae. Maxilliped coxa and basis with fimbriate border, fimbriate process on basis. P1 without conspicuous denticulate peg fields on endopod. In its natural position P5 appears falciform (lanceolate) and reaches beyond the caudal rami to touch its fellow posteriorly, but when detached it is ovate or oblong, its posterior extremity is rounded or truncated, not acute.

**Males.** Anterior outline of cephalosome truncated with medial convexity. Hyaline border and dorsal pits as for female.

Caudal rami quadrate, posterior border not oblique, setation as for female but terminal setae 2 and 3 not parallel to posterior border.

First pilose seta on mandibular palp not swollen. P2 endopod with 2 plumose setae on terminal article, spinose seta absent. P5 rhomboid with 6 terminal setae.

**Species composition.** *Acutiramus acuticaudatus* (Thompson & Scott, 1903); *A. brevicaudatus* (Thompson & Scott, 1903); *A. ovatus* (Geddes, 1968) (not Haller, 1879); *A. rufolineatus* n.sp.; *A. quinquelineatus* n.sp.

**Remarks.** The features which distinguish this genus from *Porcellidium* are the rhomboid caudal rami with oblique terminal border and apical fourth seta, and the fifth limbs (P5) which wrap round behind the caudal rami. The urosome is relatively narrow and appears more pointed due to the narrow triangular posterior lobe. Although the urosome may be short, the caudal rami are not excluded from the caudal arch. The egg mass may not be completely covered by the urosome, but in such cases the eggs are covered by the expanded P5 limbs.

The generic name refers to the pointed caudal rami (*L. acutus* = pointed + *ramus* = branch, oar).

### *Acutiramus rufolineatus* n.sp.

Figs 22-24

population 144 females (116 carrying eggs), 71 males (5 coupled to juvenile females)]. Taken from *Lobophora variegata* below MLWN tide level, Broulee rock platform, Broulee, NSW (35°52'S 150°11'E), 22 Nov. 1976, V.A.P. Harris.

**Diagnosis.** *Adult female.* Amber yellow with red dorsal stripe; mean length 0.52 mm, rostrum width 0.06 mm, ratio of cephalosome width to rostrum 4.8; cephalosome with medial prominence above rostrum; dorsal surface pitted; urosome plus caudal rami heart shaped, no lateral notch; caudal rami rhomboidal with oblique posterior border, terminal setae 1, 2 and 3 lie parallel to edge (difficult to see), 4 at apex of ramus; no peg field on endopod of P1; P5 rectangular with rounded corners, extends beyond urosome and caudal rami.

*Adult male.* Lateral corner of antennule socket prominent, continued as an 'epaulet' to rounded shoulders; caudal ramus quadrate, posterior border not oblique; antennule with ventral blade.

**Dimensions.** *Females.* Mean length 0.52 mm (SD = 0.013, N = 20), cephalosome length 0.28 mm, width 0.31 mm (SD = 0.007), height 0.07 mm, body length to width ratio 1.67. Rostrum 0.06 mm wide, ratio of body width to rostrum 4.8. Urosome width to length ratio 1.3. Caudal ramus length to width ratio 2.3.

*Males.* Mean length 0.48 mm (SD = 0.012, N = 20), cephalosome length 0.25 mm, width 0.28 mm (SD = 0.007), height 0.07 mm, body length to width ratio 1.72.

**Adult female** (Fig. 22A). Anterior outline of cephalosome semicircular, bulges in midline over narrow rostrum, lateral angle of antennule socket visible from above (Fig. 23B). Body narrows posteriorly giving animal an ovate (egg shaped) outline. Hyaline border of cephalosome 5  $\mu$ m wide, dorsal surfaces with shallow pits 2.5  $\mu$ m in diameter.

Urosome plus caudal rami heart shaped in outline (Fig. 23A); boundary between anterior and posterior lobes indistinct, indicated by scar, no lateral notch, posterior lobe bordered with fine setules, apex acutely rounded. Caudal arch deep (one-third length of urosome).

Caudal rami rhomboidal with oblique terminal border (Fig. 23D), terminal seta 4 pinnate, situated at bluntly pointed apex, seta 1 and  $\gamma$  seta tend to lie parallel to oblique edge and are difficult to see, 2 and 3 recessed in border (seldom clearly visible), terminal fringe of setules present but difficult to see (compare with description of male).

Limbs with typical setation. Spatulate claw on endopod of antenna serrated, terminal portion of geniculate setae plain (Fig. 23E). Mandible as shown in Figure 23I. Maxillule (Fig. 23H) with 4 setae on proximal endite, 3 on each of the other endites. Maxilla as shown in Figure 23G. Maxilliped with medial coxal lobe rounded, border of coxa and basis fimbriate, fimbriate process on basis (Fig. 23F). No denticulate peg fields on endopod of P1 (Fig. 23J). Terminal article of P2 endopod with sabre-like serrulate spinous seta

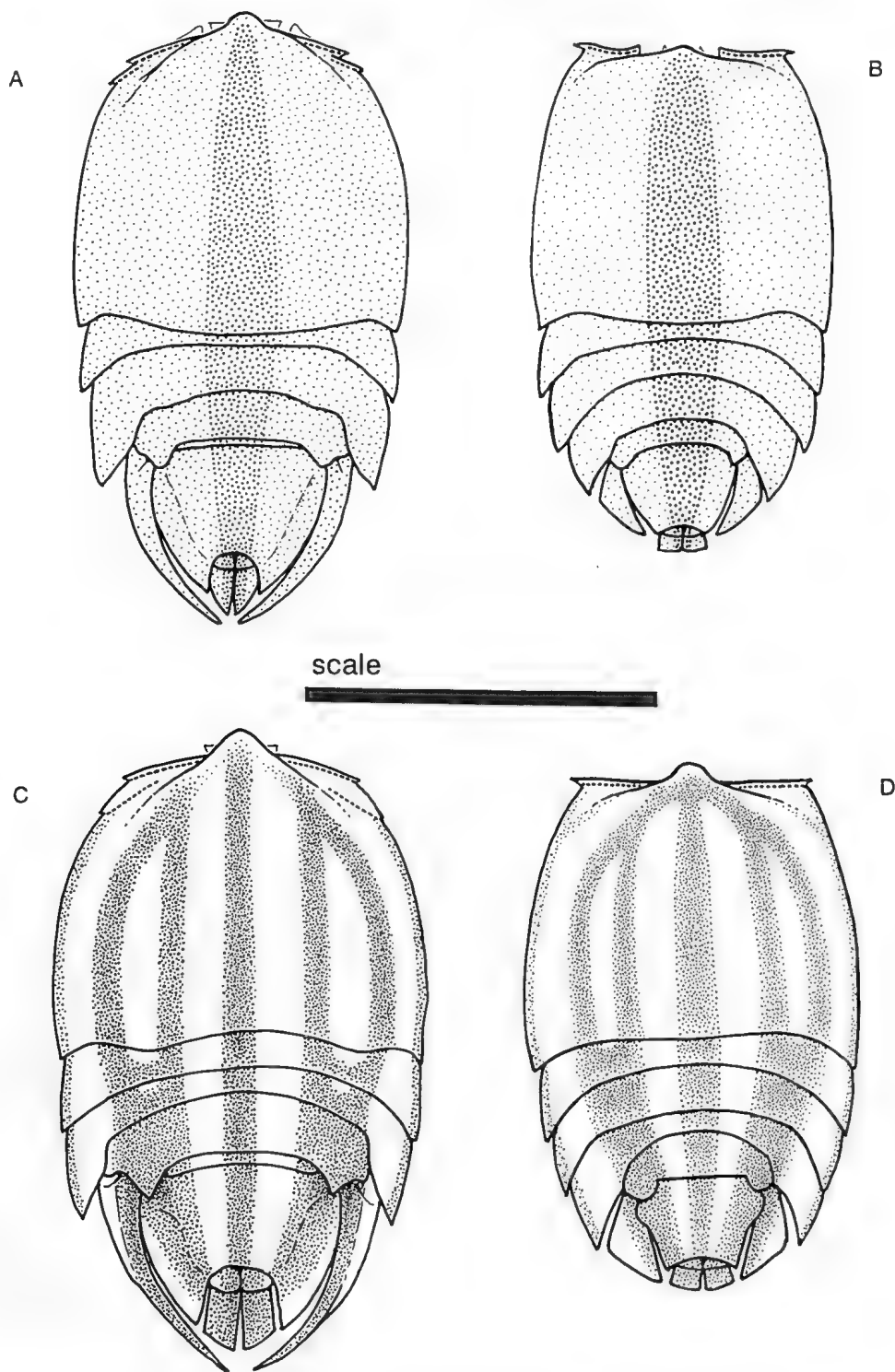
**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35448; ALLOTYPE adult male, AM P35449; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35450; 4 female and 4 male paratypes [Br.69] BM(NH) 1992.484-491, (other material [Aw 12] BM(NH) 1992.492-501). Dissections from which illustrations were made have been designated paratype material (slides 1170, 1171 female, 1173 male); these and remaining type population held at ZANU, registration Po.G.[Br.69] [total type



(Fig. 24A). Sabre-like spinous seta on P3 endopod much longer than endopod (1.6:1). P4 as in Figure 24C. Distal article of P5 rectangular with rounded posterior corners when removed and laid flat (in their natural position they appear falciform and wrap round behind the urosome and caudal rami to touch posteriorly), lateral

border with strong setules, 1 terminal seta (Fig. 24F).

**Adult male (Fig. 22B).** Anterior outline of cephalosome a truncated ellipse, strongly bowed forward in the midline; lateral angle of antennule socket prominent, continued laterally as distinct 'epaulet', shoulder angular



**Fig. 22.** *Acutiramus rufolineatus*: A – adult female, dorsal view; B – adult male, dorsal view. *Acutiramus quinquelineatus*: C – adult female, dorsal view; D – adult male, dorsal view. Scale bar: A,B = 0.32 mm; C,D = 0.34 mm.



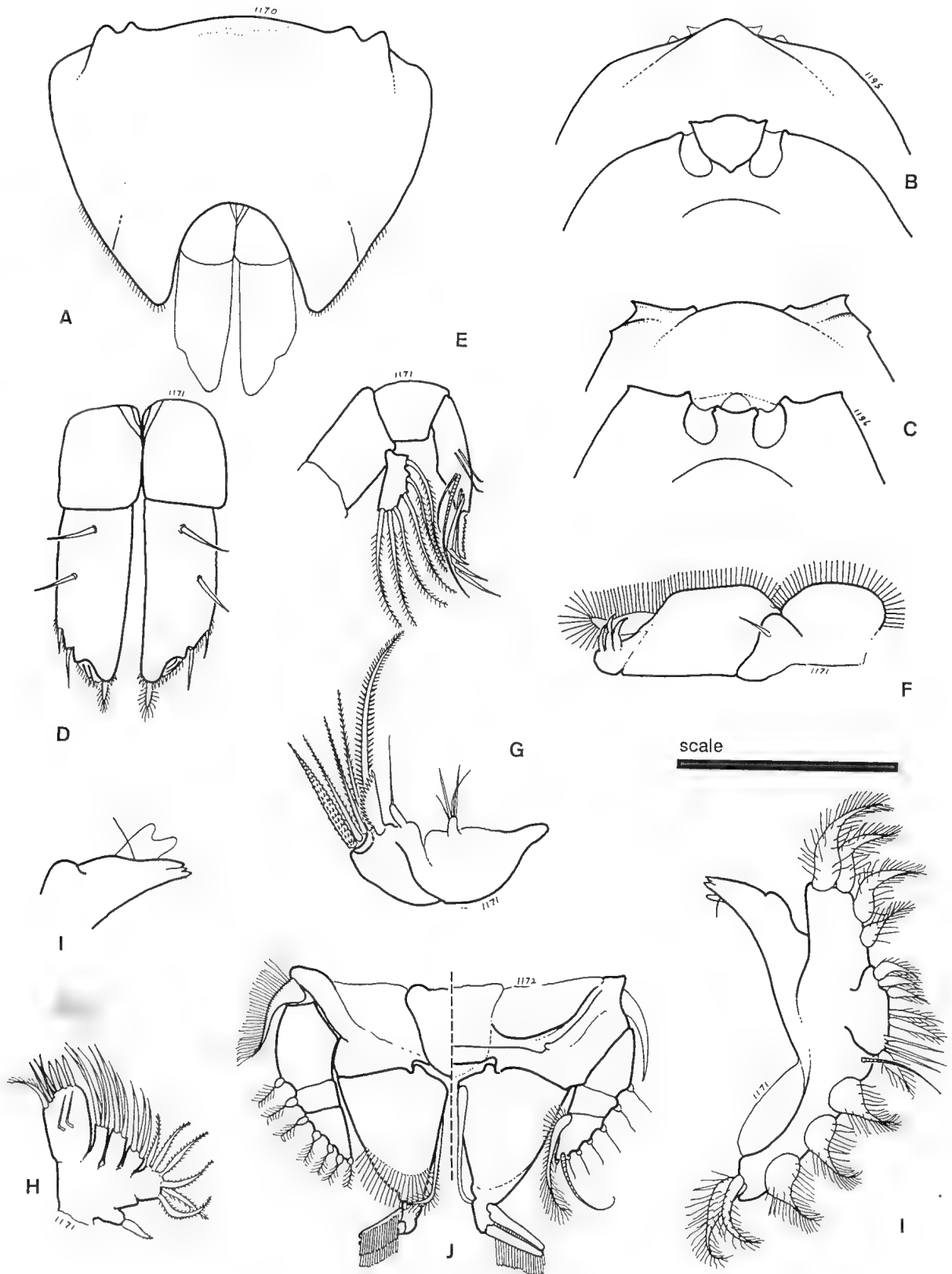


Fig. 23. *Acutiramus rufolineatus*. A – female urosome; B – anterior edge of female cephalosome (dorsal and ventral focus); C – anterior edge of male cephalosome (dorsal and ventral focus); D – female caudal rami; E – antenna; F – maxilliped; G – maxilla; H – maxillule; I – female mandible and incisor process; J – P1, anterior - left, posterior - right. Scale bar: A, J = 0.1 mm; B, C = 0.2 mm; D = 0.075 mm; E, I = 0.065 mm; F, G, H = 0.055 mm.

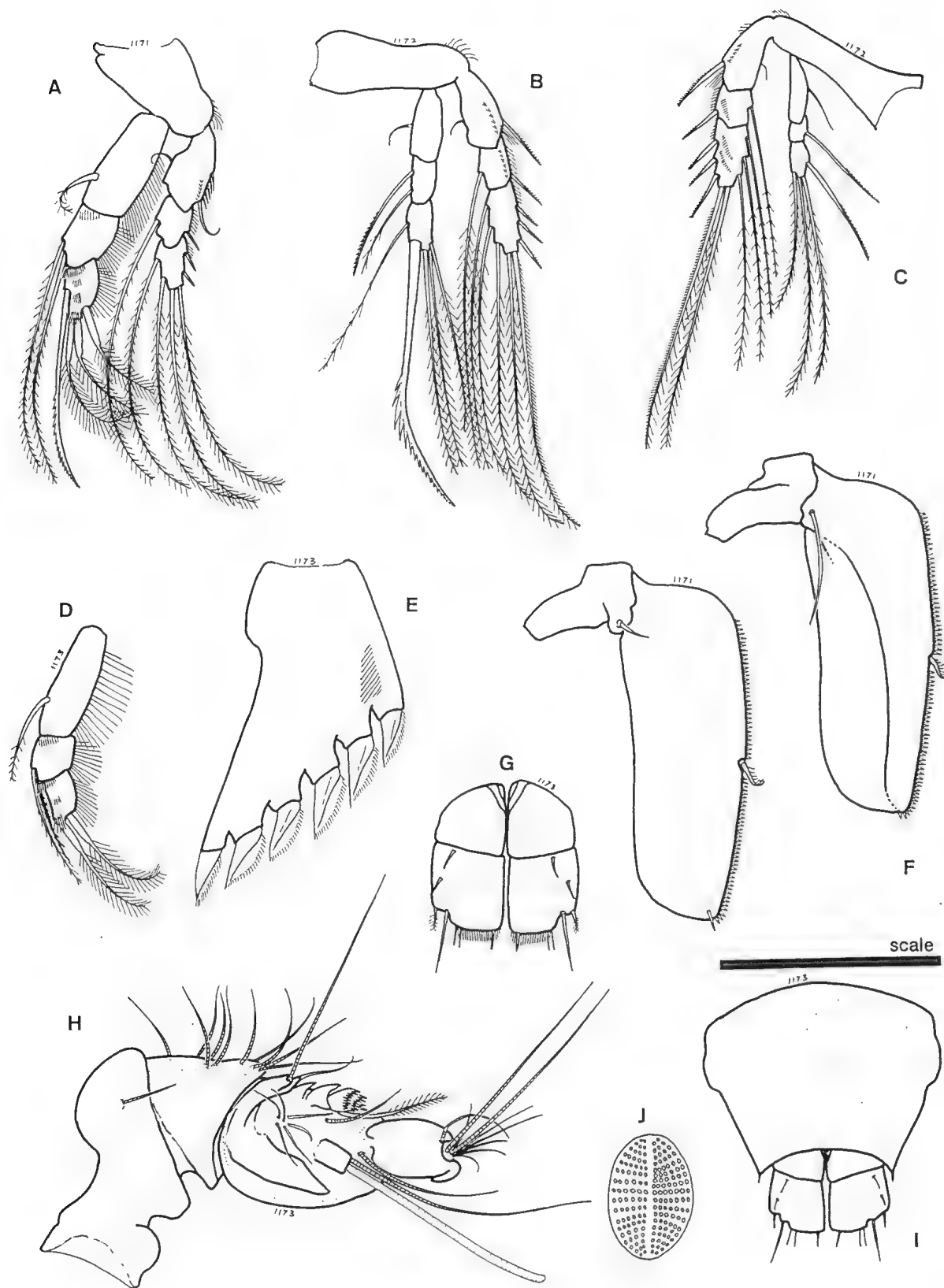


Fig. 24. *Acutiramus rufolineatus*. A – female P2; B – P3; C – P4; D – male P2 endopod; E – male P5; F – female P5 (dorsal and ventral); G – male caudal rami; H – male antennule showing coupling denticles; I – male urosome; J – diatom from dorsal surface of *A. rufolineatus*. Scale bar: A,B,C,D,I = 0.1 mm; E,H = 0.055 mm; F = 0.125 mm; G = 0.075 mm; J = 0.03 mm.

(Fig. 23C). Hyaline border and dorsal pits as in female. Urosome as in Figure 24I.

Caudal rami almost quadrate, posterior border not oblique (Fig. 24G), lateral corner emarginate, terminal seta 1 pinnate, 2 and 3 plain close together, 4 plain set in from medial corner, terminal fringe of fine setules present.

Antennules typically modified (Fig. 24I). Three small coupling denticles, distal denticle with finely serrated distal edge. Ventral blade present, half length of compound segment. Terminal segment half length of compound segment.

First pilose seta of mandibular palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 24D). Terminal setae of P5 deltoid with medial ridge and serrulate lateral border (Fig. 24E).

**Remarks.** The trivial name refers to the red dorsal stripe which runs from rostrum to caudal rami (*L. rufus* = red + *linea* = a line); the rest of the body is amber yellow. In males the antennules and anterior edge of the cephalosome may be red. Occasionally individuals are found which lack the red stripe.

Individuals detached from seaweed swim briefly then roll into a ball like a pill woodlouse (ie, conglobate), sink to the bottom and remain motionless for a short period before righting themselves. An oval diatom 16  $\mu$ m long is commonly found living on the dorsal surface (Fig. 24J); it appears to be specific to *A. rufolineatus* and has not been found on *A. quinquelineatus* or *P. pulchrum*.

This species is easily distinguished from the similarly coloured *P. pulchrum* by its small size, heart-shaped urosome, P5 reaching beyond caudal rami, epaulets on the male and the ability to conglobate.

**Distribution and abundance.** *Acutiramus rufolineatus* is a common and widespread species recorded from Ballina in the north of NSW to Moruya in the south, but it has not been recorded for Merimbula or Twofold Bay.

Large populations (greater than 100) are found on *Lobophora variegata* in tide pools about LWN tide level, but not on *Hormosira* growing in the same pools. Large populations are also encountered on *Ecklonia radiata* in the infralittoral fringe. Occasionally isolated individuals may be found on *Sargassum*, *Colpomenia*, *Cystophora*, *Phyllospora* and encrusted stones.

#### *Acutiramus quinquelineatus* n.sp.

Figs 22, 25, 26

**Type material.** HOLOTYPE adult female with egg-mass detached, AM P35451; ALLOTYPE adult male, AM P35452; PARATYPES 3 ovigerous females, 2 males and 1 male coupled to juvenile female, AM P35453; 2 female and 2 male paratypes [Br.85] BM(NH) 1992.502-505, (other material [Tb

7] BM(NH) 1992.506-515). Dissections from which illustrations were made have been designated paratype material (slides 1222, 1158 female, 1156 male); these and remaining type population held at ZANU, registration Po.U.[Br.85] [total type population 19 adult females (12 carrying eggs), 15 males (3 coupled to juvenile females)]. Taken from holdfasts of *Ecklonia radiata* in the infralittoral fringe at edge of Broulee rock platform, Broulee, NSW (35°52'S 150°11'E), 14 Sept. 1982, V.A.P. Harris.

**Diagnosis.** *Adult female.* White with 5 pink lines down back; mean length 0.55 mm, rostrum width 0.07 mm, ratio of cephalosome width to rostrum 4.8; cephalosome with medial prominence above rostrum; conspicuous pits on dorsal surface; urosome plus caudal rami triangular in outline, distinct lateral notch and cleft, posterior lobe pointed; caudal rami rhomboidal, divergent, posterior border oblique,  $\beta$  seta halfway down ramus, terminal seta 4 pinnate situated at apex, 2 and 3 fine close together; no peg field on endopod of P1; P5 not pointed with notch in blunt apex, extends beyond caudal rami to meet fellow posteriorly.

*Adult male.* Shoulders with prominent 'epaulet'; caudal rami quadrate; small ventral blade on antennule.

**Dimensions.** *Females.* Mean length 0.55 mm (SD = 0.012, N = 18), cephalosome length 0.29 mm, width 0.34 mm (SD = 0.012), height 0.09 mm, body length to width ratio 1.6. Rostrum 0.07 mm wide, ratio of body width to rostrum 4.8. Urosome width to length ratio 1.3. Caudal ramus length to width ratio 3.0.

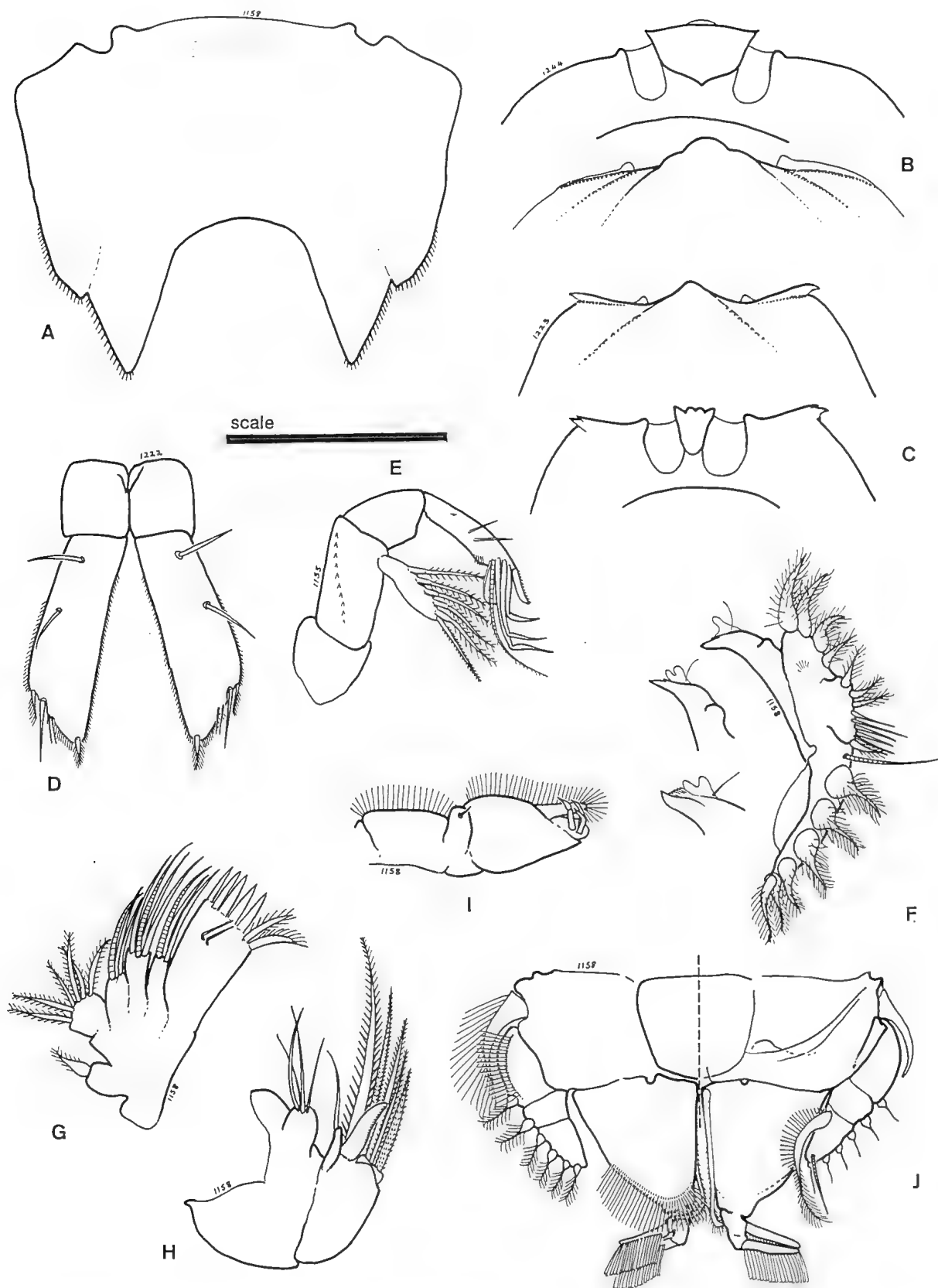
*Males.* Mean length 0.43 mm (SD = 0.011, N = 14), cephalosome length 0.25 mm, width 0.3 mm, body length to width ratio 1.43.

**Adult female** (Fig. 22C). Anterior outline of cephalosome semicircular with prominent hump or protuberance in midline, lateral angle of antennule socket projects slightly (Fig. 25B). Rostrum narrow, not prominent, slightly bowed anteriorly with acute corners. Hyaline border of cephalosome and epimeral lobes 7  $\mu$ m wide, dorsal pits conspicuous, 3  $\mu$ m in diameter. Dorsal surface of caudal rami with reticulate pattern of ridges.

Urosome (Figs 22C, 25A) plus caudal rami triangular in outline; distinct lateral notch and cleft, posterior lobe pointed, fine setules on posterior half of lateral border. Caudal arch deep (about half urosome length).

Caudal ramus rhomboidal, divergent (Fig. 25D), slightly wider posteriorly with oblique distal border, fine setules along most of medial and lateral borders.  $\alpha$  seta less than one-fifth and  $\beta$  seta less than halfway down ramus, terminal seta 4 pinnate situated at apex, 2 and 3 plain close together, seta 1 unipinnate at external corner; terminal fringe of fine setules present. Rami project well beyond urosome, but are surrounded by fifth limbs (see Fig. 22C).

Limbs with typical setation. Antenna (Fig. 25E) with spatulate claw on endopod finely serrated, geniculate setae plain. Mandible slender (Fig. 25F). Maxillule with 3 setae on proximal and distal endites, 4 setae on medial



**Fig. 25.** *Acutiramus quinquelineatus*. A – female urosome; B – anterior edge of female cephalosome (ventral and dorsal focus); C – anterior edge of male cephalosome (dorsal and ventral focus); D – female caudal rami; E – antenna; F – female mandible and incisor process from different angles; G – maxillule; H – maxilla; I – maxilliped; J – P1, anterior - left, posterior - right. Scale bar: A,B = 0.165 mm; C,D,F = 0.1 mm; E = 0.065 mm; G,H = 0.045 mm; I = 0.075 mm; J = 0.09 mm.

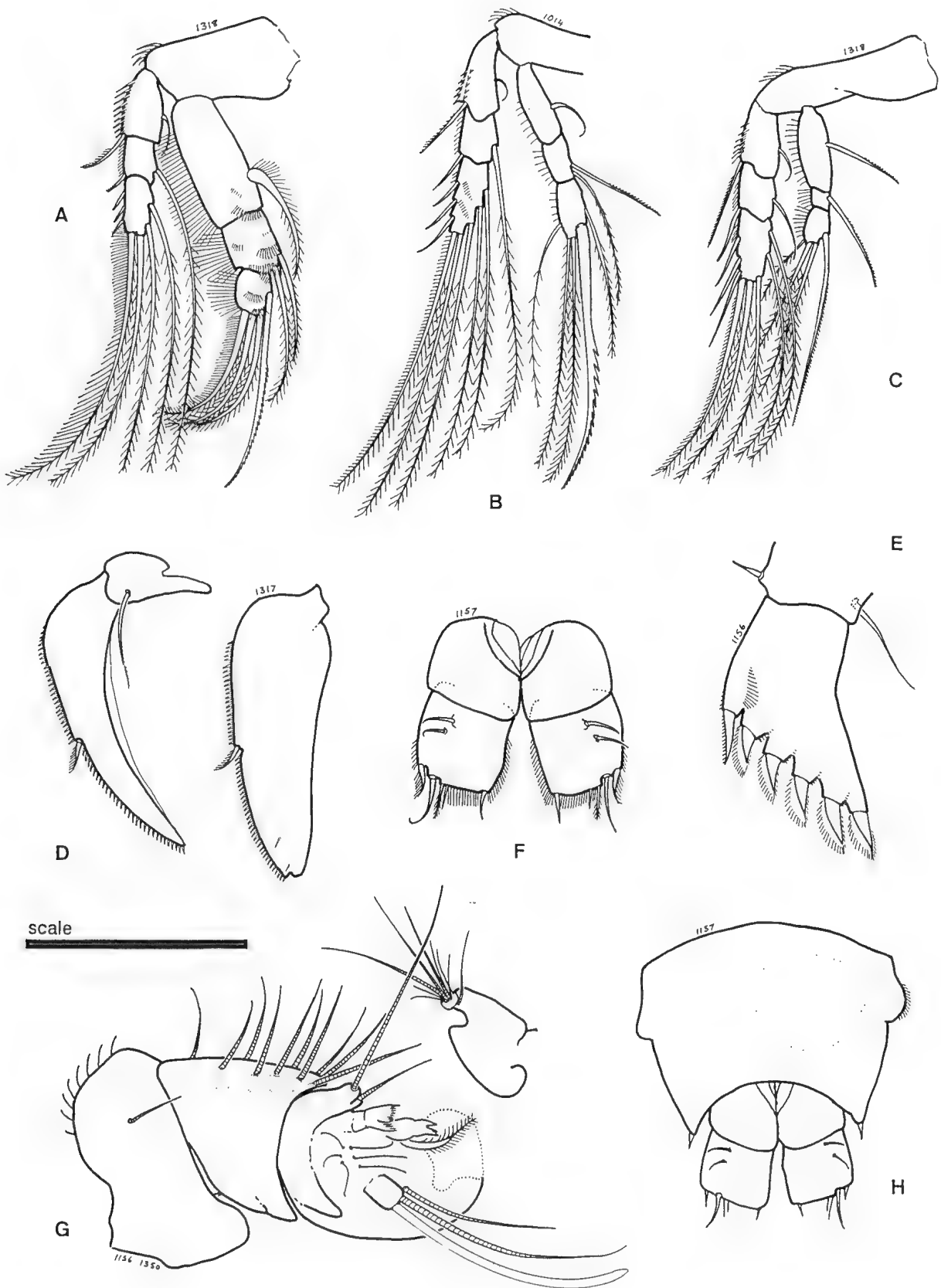


Fig. 26. *Acutiramus quinquelineatus*. A – female P2; B – P3; C – P4; D – female P5 (ventral and dorsal); E – male P5; F – male caudal rami; G – male antennule, terminal segment displaced to show coupling denticles; H – male urosome. Scale bar: A,B,C,H = 0.1 mm; D = 0.165 mm; E = 0.065 mm; F = 0.075 mm; G = 0.055 mm.

endite, single seta on exopod (Fig. 25G). Maxilla as shown in Figure 25H. Medial lobe of maxilliped (Fig. 25I) rounded with fimbriate edge, fimbriate process present on basis. P1 without denticulate peg fields (Fig. 25J). Terminal article of P2 endopod with sabre-like serrulate spinous seta (Fig. 26A). Sabre-like spinous seta on P3 (Fig. 26B) considerably longer than endopod (1.6:1). P4 with first internal seta on distal article of endopod serrulate spinous (Fig. 26C). P5 lanceolate, apex obtuse with notch, 2 dorsal apical setae (Fig. 26D).

**Adult male** (Fig. 22D). Anterior outline of cephalosome a truncated ellipse, prominent medial dorsal protuberance projects forward in the midline, strongly developed 'epaulets', shoulders angular, lateral angle of antennule socket not prominent (Fig. 25C). Hyaline border and dorsal pits as in female.

Urosome as in Figure 26H; strong apical setule present.

Caudal ramus quadrate (Fig. 26F), slightly emarginate, posterior border not oblique, terminal seta 1 unipinnate, 2 pinnate, 3 and 4 plain, 2 and 3 close together, terminal fringe of fine setules present.

Antennule (Fig. 26G) typically modified. Coupling apparatus reduced to 2 small denticles, proximal with finely serrated edge, distal bicuspid, tooth-like, with associate plumose seta. Small ventral blade (less than quarter length of compound segment). Terminal segment with notch near tip.

First seta on mandibular palp slender. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod. First lateral seta of P5 slender unipinnate, remainder triangular with pinnate lateral fringe, row of setules at base of each seta (Fig. 26E).

**Remarks.** The trivial name *quinquelineatus* refers to the five magenta pink stripes that run down the back (*L. quinque* = five + *linea* = a line). Spirit preserved specimens lose their colour and resemble *A. rufolineatus* in size and appearance; but are distinguished by the shape of the fifth limbs (P5).

**Distribution and abundance.** *Acutiramus quinquelineatus* has been recorded from all New South Wales sampling stations ranging from Ballina in the north to Twofold Bay in the south. Although no large populations have been found, nearly all specimens have been taken from *Ecklonia radiata* where it is significantly more abundant on the holdfast and stipe than the thallus, however, Robertson has observed that animals migrate down onto the stipe and holdfast at low tide if the weed is partly exposed and move back to the thallus as the tide returns.

## Discussion

### Taxonomic Characters

A number of new characters for the Porcellidiidae

have been used in the foregoing descriptions which require further explanation or discussion. Of particular significance are the shape of the cephalosome, structure of the urosome, shape and setation of the caudal rami and peculiarities of the limbs.

1. The cephalosome. There is relatively little specific difference in the shape of the anterior border of the female cephalosome, it is usually semicircular or semi-elliptical; rarely truncated. In marked contrast the anterior border of the male cephalosome is usually truncated and shows a wide range of features (the shape of the shoulders, prominence of the antennule socket, presence of an 'epaulet' or extension of the anterior border at the point where the hyaline border starts, etc.). These features offer a quick and positive way of distinguishing species where the females look very similar (for example, spirit specimens of *P. hormosirii*, *P. ocellum* and *P. pulchrum*, see Figs 3A,G; 7A-D).

In the majority of species the lateral border of the cephalosome and epimeral lobes is bordered by a colourless, hyaline fringe which appears to be non-chitinous as it does not stain with the chitin stain chlorazol black. A few sensory setae appear to lie in the plane of the hyaline border, and the ducts of marginal glands open on the dorsal surface immediately above it. However, the lateral edge of the cephalosome may be reflexed ventrally so that it is not visible from above and the hyaline border reduced or lost (Harris, 1994). The hyaline border has not been drawn in any of the illustrations.

A wide range of surface ornamentation is found on the dorsal parts of the body, including the caudal rami. In the majority of species this consists of circular, oval or semicircular pits, sometimes with a raised border (see Pl. 1A), which give the animal a malleated or pockmarked appearance. Sometimes the area between pits may be raised into reticulate ridges, particularly on the urosome and caudal rami. In a few species pits are absent, in which case the surface may be smooth or raised into a honeycomb-like ornamentation of ridges. No differences have been found in the hyaline fringe or ornamentation between males and females.

2. The urosome. In the majority of species the female genital segment of the abdomen is expanded into anterior and posterior lobes by lateral epimeral expansions. A cleft, notch or scar may indicate the boundary between lobes, and the degree of fusion that has taken place. Fusion may be so complete that there is no trace of anterior and posterior lobes. Epimeral lobes may be absent, in which case the urosome is narrow, without a caudal arch, and the caudal rami completely excluded from the urosome. Epimeral lobes appear to be absent from males where division into anterior and posterior lobes is usually indistinct. Although the shape of the urosome is difficult to quantify, the wide range in shape provides useful specific characteristics.

3. The caudal rami. The shape of the female caudal rami can be grouped into four categories: triangular (as in *P. tenuicauda* Claus, 1860), rhomboidal (as in *A.*

*rufolineatum*), rectangular (as in *P. ulvum* Hicks and *P. hormosirii*) and quadrate (as in *P. phyllosporum*). In marked contrast, the caudal rami of males is remarkably uniform and nearly always quadrate or sub-quadrate (l/w less than 1), consequently there is usually a marked difference in shape, but not setation, from the female (compare, for example, Figs 25D and 26F).

On the dorsal surface of each ramus there are two setae, here designated  $\alpha$  (proximal) and  $\beta$  (Fig. 2), which may be very close together (ie, ratio  $\alpha$  to  $\gamma/\alpha$  to  $\beta > 5$ ) as in *P. dilatatum* Hicks (Hicks, 1971), wide apart with  $\beta$  close to posterior border of ramus (subterminal) as in *P. erythrogastrum* or any intermediate position.

Along the terminal (posterior) border of each ramus there are typically five setae, but these are seldom of the same form. One of these resembles  $\alpha$  and  $\beta$  and is much longer than the others; it is never pinnate (*P. brevicaudatum* may be an exception). For these reasons this seta has been designated  $\gamma$  and included in the dorsal series (Fig. 2). The remaining setae (usually 4) are much more variable in appearance; they may be plain or pinnate (Fig. 2). They are numbered 1 to 4 with terminal seta 1 (if present) occupying the external (lateral) corner of the ramus and 4 situated at or near the medial corner. The middle setae, 2 and 3, are usually set close together and more slender than 1 and 4, but in some species (eg, *P. ulvum*, Hicks, 1982) all four setae are identical in shape and equally spaced along the terminal edge. Seta 3 may be very small and easily overlooked, but its presence in the species can be confirmed by examining the male caudal ramus where it will be of similar size to seta 2.

Three features of the caudal ramus appear to show generic differences; viz: very close proximity of the  $\alpha$  and  $\beta$  setae or otherwise; rhomboidal shape of the lamina with oblique posterior border and seta 4 at the apex or otherwise; and both shape and placement of the four terminal setae (ie, 1-4 identical and equidistant or 2 and 3 close together and different to 1 and 4).

4. The limbs. While certain limbs offer only a limited range of form, others show wide variation. Of the former, the following appear to offer generic characteristics: maxillule (endopod\* with 2 or 6 setae), maxilliped (with fimbriate border and fimbriate process or without either), male P2 with 2, 3 or 4 terminal setae, and male P5 (with 1 or 6 terminal setae). On the other hand, denticulate peg fields on P1, ratio in length of P3 endopod and its large sabre-like spinous seta, and the shape of female P5, are features with wide variation that can be used to characterise species.

As noted by Hicks (1982), the male antennule may possess a number of features that are of potential taxonomic value, particularly the structures here referred to as the coupling denticles and a sclerotised finger-like process, the ventral blade. However, the extreme difficulty of studying the male antennule reduces the practical

value of these features in identifying specimens. The structure and homologies of the porcellidid antennule have been described by Harris (1994).

### Interspecific Relationships

Redefining the characteristics of *Porcellidium* raises the question of the relationship of previously described species, but here one is immediately faced with uncertainty for many of the characters crucial to identification have not been given in earlier descriptions and some older Type material has not been traced.

Six previously described species qualify for inclusion in the redefined genus *Porcellidium*: *P. viride*, *P. fimbriatum*, *P. sarsi*, *P. rubrum*, *P. erythrum*, *P. hartmannorum* and *P. algoense*.

There has been considerable confusion over the identity of *P. viride*, *P. fimbriatum* and *P. sarsi* in the past. This is not surprising for the original description of *viride* (*Thyone viridis* Philippa, 1840) was quite inadequate and of a juvenile male. Claus (1889) described a pale green species as *P. lecanoides* which Lang (1948) regarded as synonymous with *P. viride*. Further confusion arose because the description and illustrations Claus gave of *P. fimbriatum* Claus, 1889 did not agree with his previous inadequate account (Claus, 1863). The animal described by Sars as *P. fimbriatum* fits Claus' 1863 description rather than the 1889 description. Bocquet (1948) clearly demonstrated the differences between Sars' animal which he renamed *P. sarsi* and Claus' other two species – *P. fimbriatum* and *P. lecanoides*, all of which are perfectly valid species despite Lang's attempt to synonymise all three as *P. viride* (Lang, 1948). Although females of *P. viride* (*P. lecanoides* Claus) and *P. sarsi* look very similar in shape, they can easily be separated on the structure of the male's antennule, moreover, both species can be distinguished from *P. fimbriatum* on the structure of their urosome, setation of the caudal rami and the colouration of living animals. Table 3 shows the main features which separate these three species.

Their broad urosome, rectangular caudal rami, maxillule endopod with six setae, maxilliped with fimbriate process, male P2 with two terminal setae, male P6 with six setae, and hyaline fringe to the cephalosome, confirm *P. viride*, *P. fimbriatum* and *P. sarsi* as species in the genus *Porcellidium* as defined above. The absence of a ventral blade on the male antennule would place *P. viride* and *P. sarsi* in the 'Naviculum' subgroup, but *P. fimbriatum*, which has a ventral blade to the antennule, cannot be placed in the 'Hormosirii' subgroup because its terminal setae on the caudal ramus are different; it will be placed in a subgroup of its own, the 'Fimbriatum' subgroup.

*Porcellidium rubrum* Pallares (1966), *P. hartmannorum* Tiemann (1978) and *P. algoense* Hicks (1982) also display all the previously listed characters of the redefined genus *Porcellidium*, and all possess a ventral blade to the male antennule which places them

\* The maxillule is interpreted differently by Humes & Ho (1969) who describe this structure as the exopod.



in the 'Hormosirii' subgroup. There is some doubt about the position of *P. erythrum* Hicks. Hicks (1982) states that males do not have a finger-like lateral process (ventral blade) which would place it in the 'Naviculum' subgroup, however, topotype material examined by the authors do appear to have a ventral blade and further study is required to determine its true affinities. Interpretation of this structure can be difficult and largely dependent upon orientation of the antennule.

Five species have been described which resemble *Acutiramus rufolineatus* in having a rhomboidal caudal ramus and fifth limbs (P5) that pass behind the caudal rami. Of these *P. scutatum* Claus 1889, and *P. ravanae* Thompson & Scott, 1903 are not described in sufficient detail to be certain about their affinities. *Porcellidium brevicaudatum* Thompson & Scott, 1903 has been accurately redescribed by Humes & Ho, 1969, and although the description of *P. ovatum* Geddes, 1968 (not Haller, 1879), lacks some important information, it gives sufficient detail for comparison with other species. The last of the five species, *P. acuticaudatum* Thompson & Scott, 1903, was inadequately described for comparison, but specimens from Lake Timsâh, Ismalia, collected by Wells (1967) were referred to this species. This material in the BM(NH) has been examined by the senior author for comparison with *A. rufolineatus*.

*Porcellidium acuticaudatum*, *P. brevicaudatum* and *P. ovatum* (Geddes, not Haller) all possess the following characteristics which have been used to define the genus *Acutiramus*: urosome with posterior lobe narrow, triangular, male P2 with two terminal setae, male P5 with six setae, maxillule with six setae on the endopod, maxilliped with fimbriate process, cephalosome with hyaline fringe, female caudal rami rhomboidal with oblique posterior border and seta 4 apical, terminal setae 2 and 3 close together, female P5 passing behind caudal rami and possibly touching. It is suggested that these three species be removed from *Porcellidium* and placed in the new genus as *Acutiramus acuticaudatus*, *A. brevicaudatus* and *A. ovatus*. A comparison with *A. rufolineatus* and *A. quinquelineatus* is given in Table 4.

*Acutiramus brevicaudatus* differs from the others in having  $\alpha$  and  $\beta$  caudal setae close together. Another unique feature illustrated by Humes & Ho, but not found elsewhere in the Porcellidiidae, is a pinnate  $\gamma$  seta on both male and female caudal rami. This unusual feature should be re-examined for it is not unusual to find filamentous micro-organisms attached to setae and looking like pinnae. The two can be distinguished easily for, on pinnate and plumose setae, the pinnae lie at an angle to the shaft, are regularly spaced and of equal length. Filamentous micro-organisms, however, grow out at right angles, are unevenly spaced and of different lengths.

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## APPENDIX

Table 1. Taxonomic characters of the Porcellidiidae.

Constant features (family characters)	Unique characters appearing in 2 or 3 forms (generic characters)	Highly variable characters (specific characters)
form of male antennule	ventral blade on male antennule (present or absent)	denticles on male antennule shape of ventral blade
form of mandible palp	maxillule endopod with 2 or 6 setae	urosome shape
form of maxilla	maxilliped: fimbriate process present or absent	shape and setation of caudal ramus
form of P1	male P2 with 2, 3 or 4 setae on endopod terminal article	P1 peg fields on article 1 of endopod (presence and shape)
form of P3 and P4	male P5: 1 or 6 terminal setae	P3 spine/endopod ratio  shape of female P5
Body tagmosis	ability to conglobate	dimensions
Body shape	presence or absence of hyaline border*	cephalosome l/w ratio
	presence or absence of dorsal pits	dorsal ornamentation
		colouration

\* The lateral margin of the cephalosome may be reflexed ventrally and not visible from the dorsal aspect.

Table 2. Incidence of suctorian *Ophryodendron* on *P. erythrogastrum*.\*

	Females	Males	Total
number of adult copepods	86	66	152
number of parasitised copepods	56	19	75
% parasitism of sample	—	—	49%
% parasitism of copepods by sex	65%	29%	
number of suctorians	76	20	96
% distribution of suctorians between sexes	79%	21%	

\* Sample taken from population Ki.21.

Table 3. Comparison of characters.

<i>Porcellidium viride</i>	<i>Porcellidium sarsi</i>	<i>Porcellidium fimbriatum</i>
terminal setae 2 and 3 of caudal rami fine, close together	terminal setae 2 and 3 of caudal rami fine, close together	terminal setae 2 and 3 of caudal rami thick pinnate, not close together
urosoma with notch and scar, but no cleft	urosoma with notch and scar, but no cleft	urosoma with deep cleft
no ventral blade to male antennule	no ventral blade to male antennule	ventral blade present on male antennule
terminal segment of male antennule short, blunt	terminal segment of antennule long, ends in 'hook'	

Table 4. Comparison of Acutiramate species.

Character	Species					
	<i>Acutiramus rufolineatus</i>	<i>Acutiramus quinquelineatus</i>	<i>Porcellidium acuticaudatum</i> <sup>2</sup>	<i>Porcellidium acuticaudatum</i> <sup>3</sup>	<i>Porcellidium ovatum</i> <sup>1</sup>	<i>Porcellidium brevicaudatum</i> <sup>4</sup>
length	0.52 mm	0.56 mm	0.6 mm	0.6 mm	0.62 mm	0.78 mm
l/w ratio	1.67	1.6	1.5	1.7	1.5	1.66
w/rostrum ratio	(mean for 12 other species = 3.87, range 2.6-4.7)					
	4.8	4.8	4.4	4.5	4.7	4.2
female urosome w/body width ratio	(mean for 13 other species = 0.6, range 0.54-0.66)					
	0.52	0.54	0.46	—	0.52	0.46
female urosome w/l ratio	—					
	1.3	1.3	1.4	1.4	1.6	1.85
female caudal ramus l/w ratio						
	2.3	2.6	2.9	2.75	3.5	1.65
female urosome						
notch	absent	notch present	very slight	notch	cleft	no notch or cleft
caudal setae 2 and 3						
parallel to edge	parallel to edge	nearly parallel to edge	—	parallel to edge	nearly parallel to edge	not parallel to edge
$\alpha$ to $\beta$	apart	apart	apart	apart	apart	very close
$\alpha$ to apex/ $\alpha$ to $\beta$ ratio						
	2.4	3.2	6.6	6.0	3.7	10.4

<sup>1</sup> Geddes, 1968; <sup>2</sup> Thompson & Scott, 1903; <sup>3</sup> Wells, 1967; <sup>4</sup> Humes & Ho, 1969.



## New Species belonging to the Family Porcellidiidae (Harpacticoida: Copepoda) from Kioloa, New South Wales, Australia

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**ABSTRACT.** Six new species referred to four new genera and one new species of *Porcellidium* belonging to the family Porcellidiidae (Harpacticoida: Copepoda) are described from Kioloa, a locality on the southern coast of New South Wales, Australia. Characteristic features defining the following new genera are given together with descriptions of new species: *Brevifrons* n.gen., *B. faviolatum* n.sp., *Kioloaria* n.gen., *K. sesquimaculata* n.sp., *Murramia* n.gen., *M. magna* n.sp., *M. bicincta* n.sp., *Tectacingulum* n.gen., *T. tumidum* n.sp. and *T. nigrum* n.sp. A new species of *Porcellidium*, *P. londonii* n.sp., is described and referred to the 'Fimbriatum' group. The structure and taxonomic significance of the hyaline fringe and male antennule are discussed together with other characters that have been used to define new genera.

HARRIS, V.A.P., 1994. New species belonging to the family Porcellidiidae (Harpacticoida: Copepoda) from Kioloa, New South Wales, Australia. *Records of the Australian Museum* 46(3): 303–340.

The family Porcellidiidae has been regarded as monotypic with all species being referred to the one genus, *Porcellidium* (Lang, 1948). In their description of eight new species from New South Wales, Harris & Robertson (1994) pointed out the need for revision of the family. Using a wider database, built upon a more detailed knowledge of the Australian species, they discussed the most suitable features upon which the family could be defined and new genera created. The taxonomic characters of *Porcellidium* were redefined and a new genus, *Acutiramus*, established to take two of the new species.

The present paper deals with a collection of seven new species from Kioloa, a locality on the southern coast of New South Wales. Six of these belong to the southern assemblage (Harris & Robertson, 1994). One species has been referred to *Porcellidium*; the other six show features which immediately exclude them from

that genus. To accommodate them four new genera have been erected and their characteristics defined. None of the previously described species fall into these new genera.

The methods of study, measurement and selection of type material, together with terminology used to describe setae, follows the procedures described by Harris & Robertson (1994). Numbers on illustrations refer to the slide from which they were drawn. On drawings of the whole animal the delicate hyaline border or fringe has been omitted. SEM photographs of formalin fixed material were taken on an Hitachi S225 ON scanning electron microscope after gold coating.

Holotypes, allotypes and paratype material have been deposited in the Australian Museum, Sydney, and paratype material deposited in the British Museum (Natural History). The remaining paratype material and

prepared slides are currently held in the Division of Botany and Zoology, School of Life Sciences, Australian National University, Canberra, Australia (ZANU) by the author.

### Systematics

#### Porcellidiidae Sars, 1904

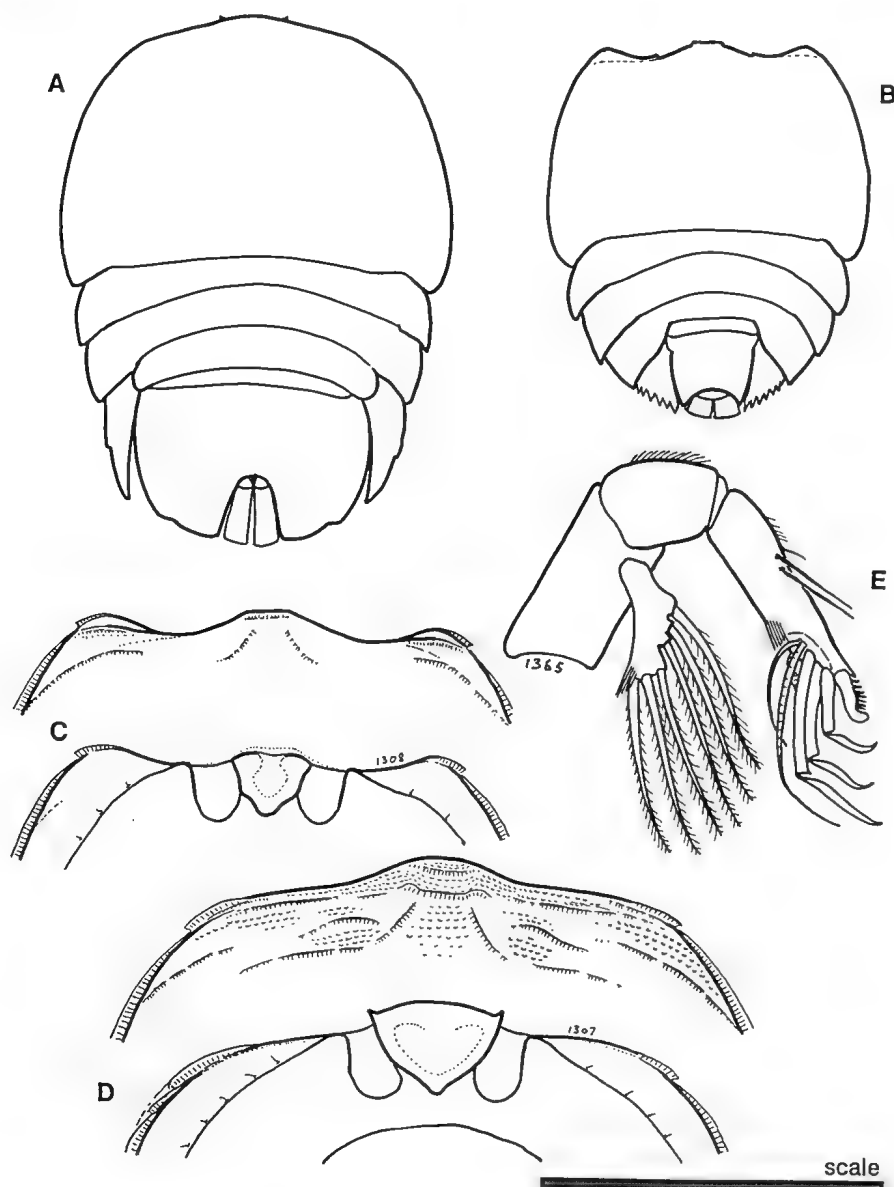
For diagnostic characters of the family see Harris & Robertson (1994).

**Generic composition.** *Acutiramus* Harris & Robertson,

1994; *Brevifrons* n.gen.; *Kioloaria* n.gen.; *Murramia* n.gen.; *Porcellidium* Claus, 1860; *Tectacingulum* n.gen.

#### *Tectacingulum* n.gen.

**Diagnosis.** Anterior of female cephalosome semicircular, male truncated; edge of cephalosome reflexed ventrally, striated false border, no true hyaline border, dorsal pits present; urosome broad, with epimeral expansions to form anterior and posterior lobes, caudal rami included in caudal arch of urosome; caudal rami rectangular not emarginate,  $\alpha$  and  $\beta$  setae not close



**Fig. 1.** *Tectacingulum tumidum*. A – adult female; B – adult male; C – male rostrum and anterior border of cephalosome (dorsal and ventral view); D – female anterior border of cephalosome and rostrum (dorsal and ventral view); E – antenna. Scale bar: A,B = 0.72 mm; C,D = 0.45 mm; E = 0.12 mm.



together; maxillule endopod with 6 setae; maxilliped basis with fimbriate process, coxal lobe fimbriate; male P2 endopod with 2 terminal setae; male P5 with 6 terminal setae; female P5 does not extend beyond the urosome or touch its fellow posteriorly.

**Species composition.** *Tectacingulum tumidum* n.sp.; *T. nigrum* n.sp.

**Remarks.** This genus differs from all other members of the family Porcellidiidae by the absence of a true hyaline border to the cephalosome. The lateral margin is reflexed ventrally and can only be seen from the

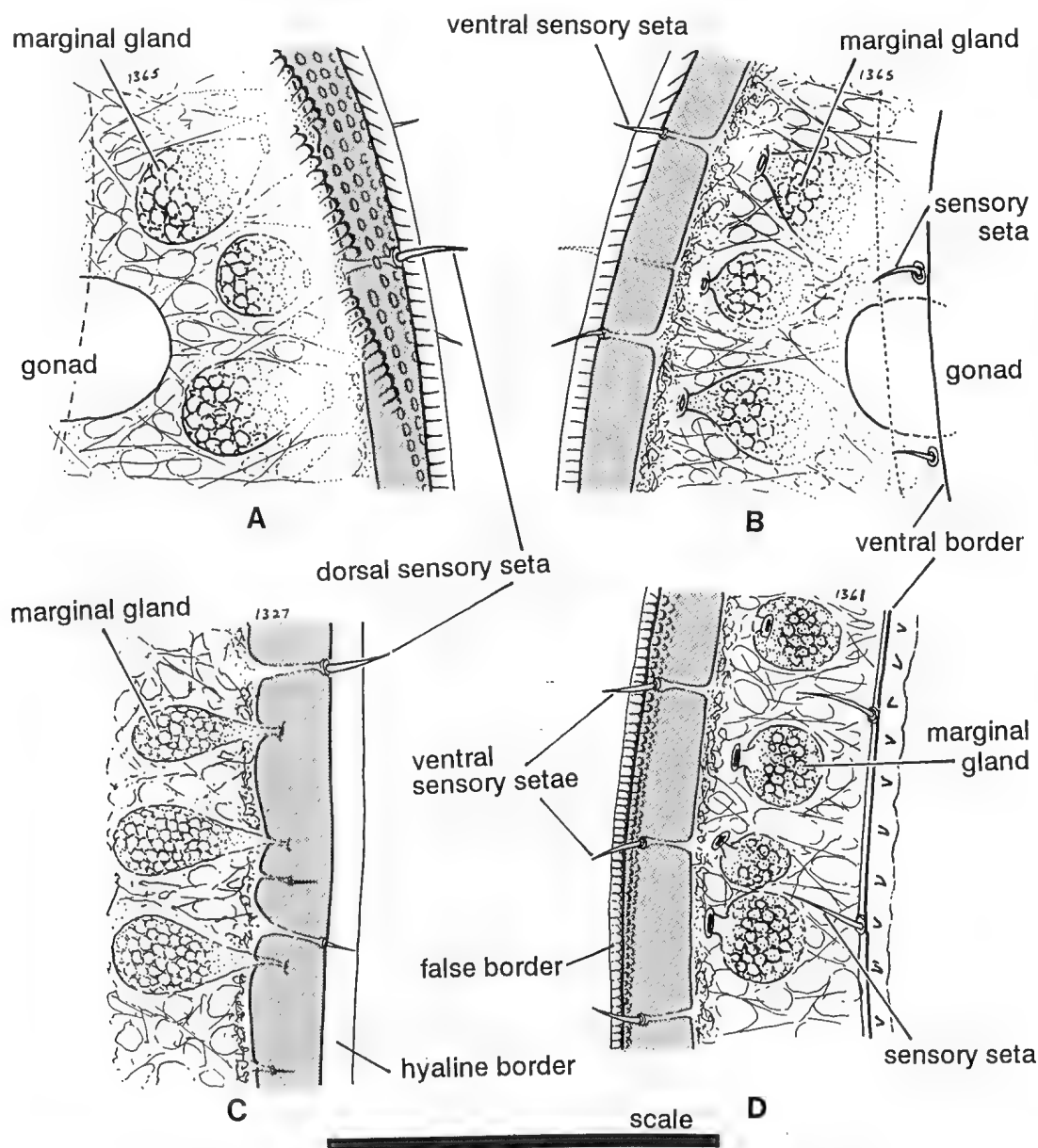
ventral side (see Fig. 2); the generic name refers to this unusual feature (L. *tectus* = hidden + *cingula* = a girdle). Consequently sensory setae, not normally found on the ventral side, are present in that position.

The two species are known from Kioloa and the southern New South Wales coast.

*Tectacingulum tumidum* n.sp.

Figs 1-5

**Type material.** HOLOTYPE adult female with egg mass,



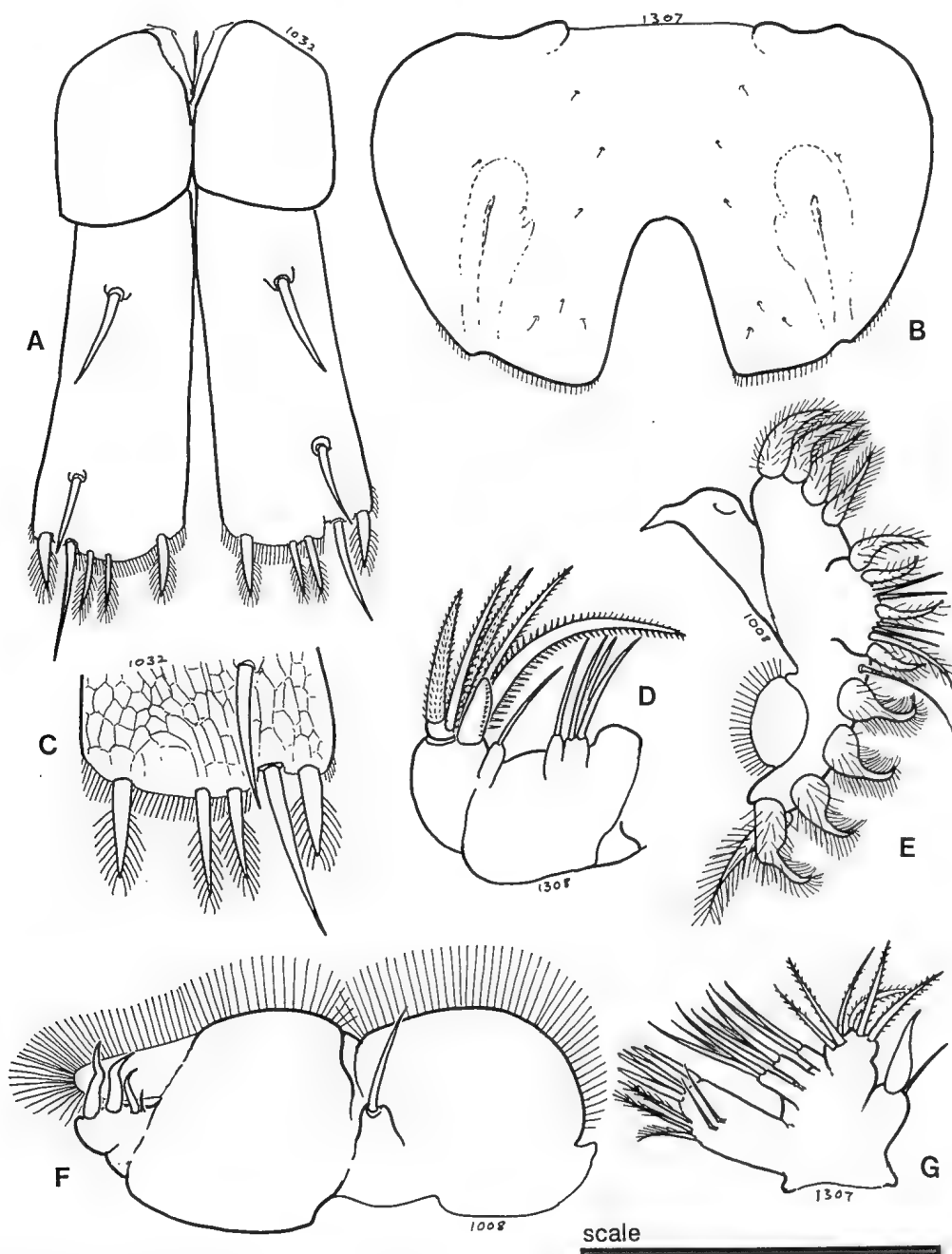
**Fig. 2.** *Tectacingulum tumidum*: A – edge of cephalosome (dorsal view) showing striated false border and absence of true hyaline fringe; B – same (ventral view) showing portion of reflexed border and ventral opening of marginal glands. *Murramia bicincta*: C – hyaline border of cephalosome (dorsal view) showing dorsal opening of marginal glands. *Tectacingulum nigrum*: D – edge of cephalosome (ventral view) showing ventral sensory setae and ventral opening of marginal glands. Scale bar: A-D = 0.1 mm.

AM P42302; ALLOTYPE adult male, AM P42303; PARATYPES 1 female, 1 male BM(NH) 1992.534-535. Dissected paratypes (slides 1307 female, 1308 male), and remaining type population, held at ZANU, registration Po.X. [Ki.35] [total type population 12 females (6 carrying eggs), 8 males 5 coupled to juveniles]. Washed from stones encrusted with pink 'Lithothamnion', infralittoral fringe, sheltered bay on north side of O'Hara Head, Kioloa, NSW (35°30'S 150°22'E), 19 Jan. 1977, V.A.P. Harris.

**Diagnosis.** *Adult female.* Translucent pale pink; mean length 1.1 mm; cephalosome noticeably wider than

metasome, rostrum 0.18 mm, ratio of width to rostrum 4.6; dorsal surface conspicuously pitted, edge of cephalosome with radiating ridges; urosome broad, semicircular, caudal arch deep, slight notch and scar; caudal rami rectangular, not emarginate, wider distally,  $\beta$  seta closer to  $\gamma$  than to  $\alpha$ , terminal setae pinnate, similar in size; extensive peg fields on P1 endopod and exopod.

*Adult male.* Cephalosome noticeably wider than metasome, shoulders rounded, project forward; antennule with ventral blade.

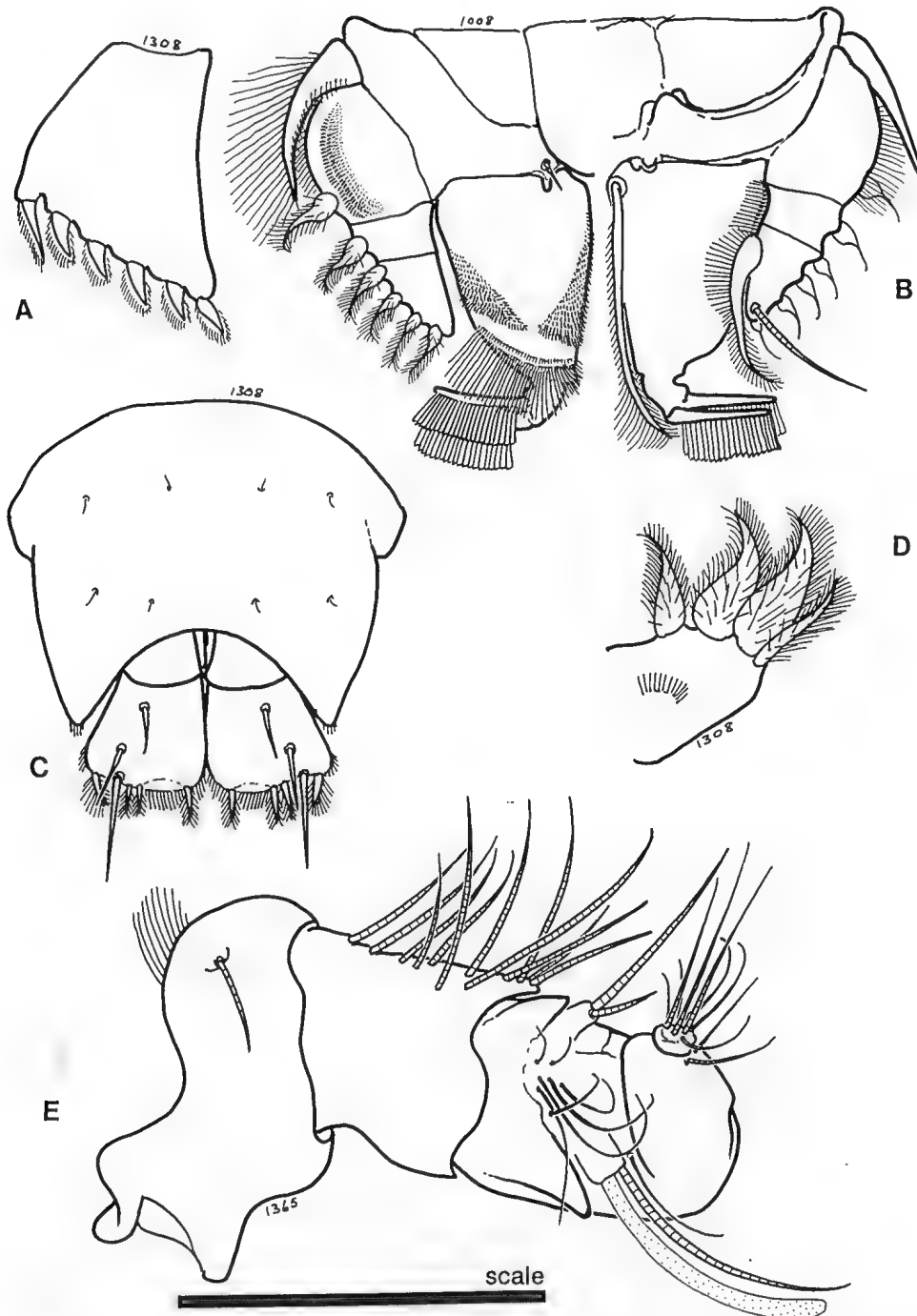


**Fig. 3.** *Tectacingulum tumidum*. A – female caudal rami; B – female urosome; C – female caudal ramus showing detail of terminal setae; D – maxilla; E – female mandible; F – maxilliped; G – maxillule. Scale bar: A,D = 0.12 mm; B,C = 0.33 mm; E = 0.22 mm; F,G = 0.1 mm.

**Dimensions. Females.** Mean length 1.14 mm (SD = 0.032, N = 9), cephalosome width 0.85 mm (SD = 0.021), height 0.15 mm, body length to width ratio 1.34. Rostrum 0.18 mm, ratio of cephalosome width to rostrum 4.6. Urosome width to length ratio 1.8. Caudal ramus length to width ratio 2.65.

**Males.** Mean length 0.76 mm (SD = 0.021, N = 7), cephalosome length 0.48 mm, width 0.66 mm (SD = 0.02), ratio of body length to width 1.15.

**Adult female (Fig. 1A).** Cephalosome very broad (about 14% wider than first metasomal segment), anterior outline semicircular with convex bulge in midline. Rostrum projects slightly (Fig. 1D). Edge of cephalosome reflexed ventrally resulting in true boundary between tergum and sternum lying ventrally. Marginal glands open ventrally and sensory setae occur on the underside (Fig. 2A,B). A true hyaline border or fringe is absent, but the thin cuticular edge of the carapace forms a false



**Fig. 4.** *Tectacingulum tumidum*. A – male P5; B – P1 (left ventral, right dorsal); C – male urosome and caudal rami; D – male mandibular palp; E – male antennule (distal segment adducted and obscuring coupling denticles). Scale bar: A,C,D = 0.19 mm; B = 0.22 mm; E = 0.1 mm.

border with radiating striations (Fig. 2A,B). Dorsal surface of cephalosome, metasome, urosome and caudal rami conspicuously pitted. Numerous dorsal sensory setae.

Urosome very broad, semicircular in outline (Fig. 3B), with slight lateral notch and scar, posterior lobe bordered with fine setules. Caudal arch deep, slightly less than half urosome length.

Caudal rami long, rectangular, not emarginate, slightly wider distally (Fig. 3A).  $\alpha$  seta one-third, and  $\beta$  seta three-quarters way down ramus; terminal setae all pinnate, 2 and 3 close, 4 set in slightly from medial

corner; terminal fringe of very fine setules (Fig. 3C). Caudal rami do not project beyond caudal arch in natural position.

Limbs with typical setation (Figs 1, 3-5). Spatulate claw of antenna pectinate, geniculate setae articulate (Fig. 1E). Incisor process of mandible chisel-like at right angles to body of mandible (Fig. 3E). Maxillule exopod with 2 setae, endopod with 6 setae (Fig. 3G). Maxilla as shown in Figure 3D. Medial lobe of maxilliped semicircular with coxal seta and fimbriate border, basis with fimbriate border and fimbriate process (Fig. 3F). First peracopod (P1, Fig. 4B), with broad band of

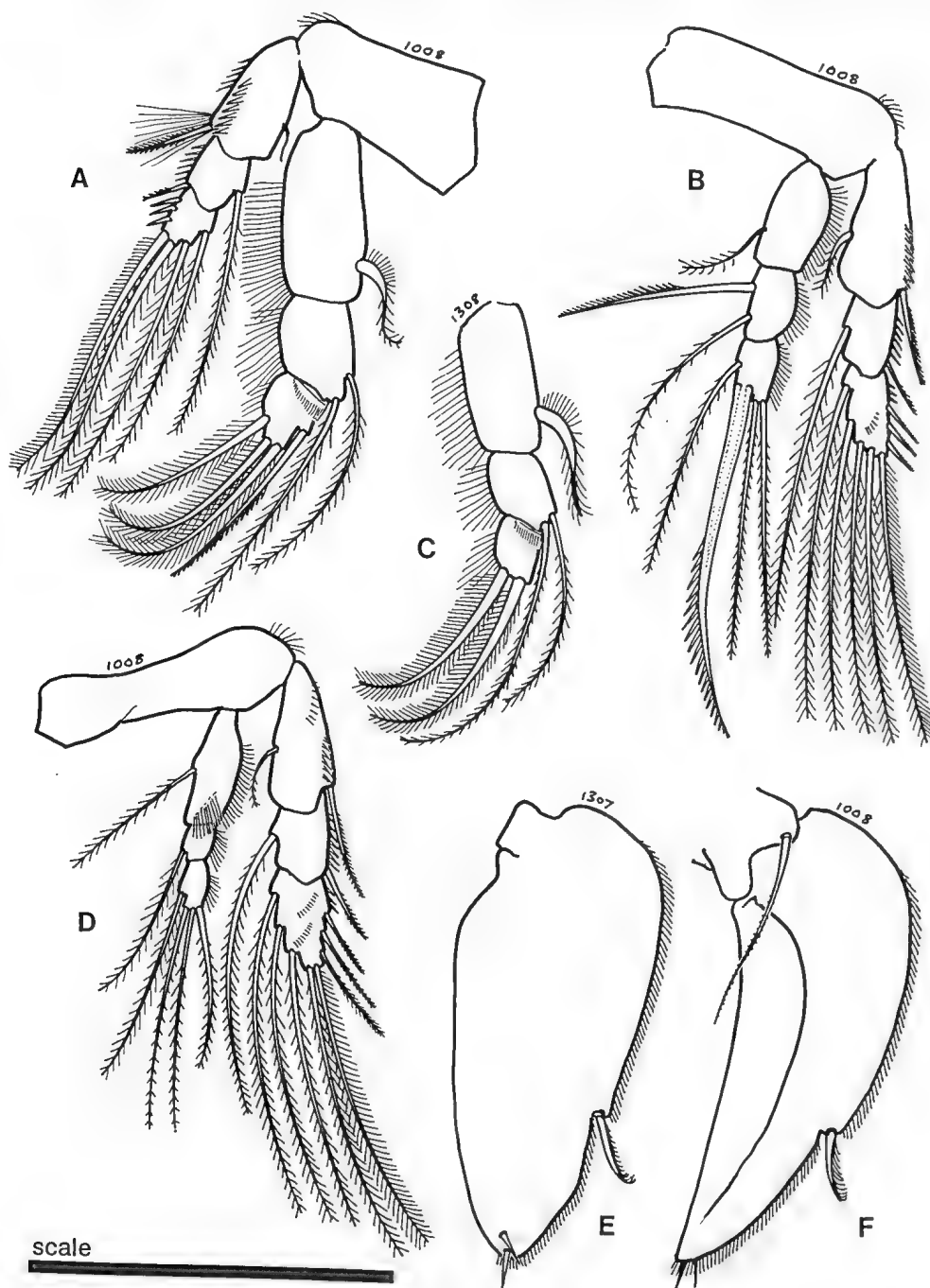


Fig. 5. *Tectacingulum tumidum*. A – female P2; B – P3; C – male P2 endopod; D – P4; E – female P5 (dorsal); F – female P5 in natural position (ventral). Scale bar: A-F = 0.22 mm.

denticulate pegs parallel to border on article 1 of exopod; field of denticulate pegs along medial border of endopod broadens distally and joins another triangular peg field lateral and proximal to fimbriate crescent. Terminal article of P2 endopod with 1 serrulate spinous seta and 3 plumose setae (Fig. 5A). Serrate sabre-like seta of P3 endopod (Fig. 5B) considerably longer than endopod (1.6 : 1). All setae of P4 endopod plumulose (Fig. 5D). Distal article of P5 lanceolate, apex rounded with 2 setae (Fig. 5E,F).

**Adult male** (Fig. 1B). Cephalosome broader than metasome, truncated anteriorly, strongly convex in midline, angle of antennule socket just visible from above, shoulders project forward, rounded with 'epaulet' (Fig. 1C). Border of cephalosome, ornamentation of pits and sensory setae as for female.

Urosome (Fig. 4C) with small group of apical setules. Caudal rami quadrate, expanding distally, setation as for female (Fig. 4C).

Antennule prehensile (Fig. 4E), short ventral blade and anterior spine on accessory lobe of compound segment, coupling denticles not known (observed in dissected specimen); first pilose seta on mandibular palp thin (Fig. 4D); maxilliped, P1, P3 and P4 as for female, P2 with 2 plumose setae on distal article of endopod (Fig. 5C); P5 with 6 setae as shown in Figure 4A.

**Remarks.** The ratio of body length to width of this species ( $l/w = 1.3$ ) is the lowest known. The greater width of the cephalosome compared to the metasome gives this species a swollen appearance (*L. tumidus* = swollen). Freshly collected specimens are a pale translucent pink, but this fades on preservation.

**Distribution and abundance.** *Tectacingulum tumidum* has only been recorded from Kioloa, NSW. Numbers collected are small (the type population is the largest encountered). It has been washed from stones and

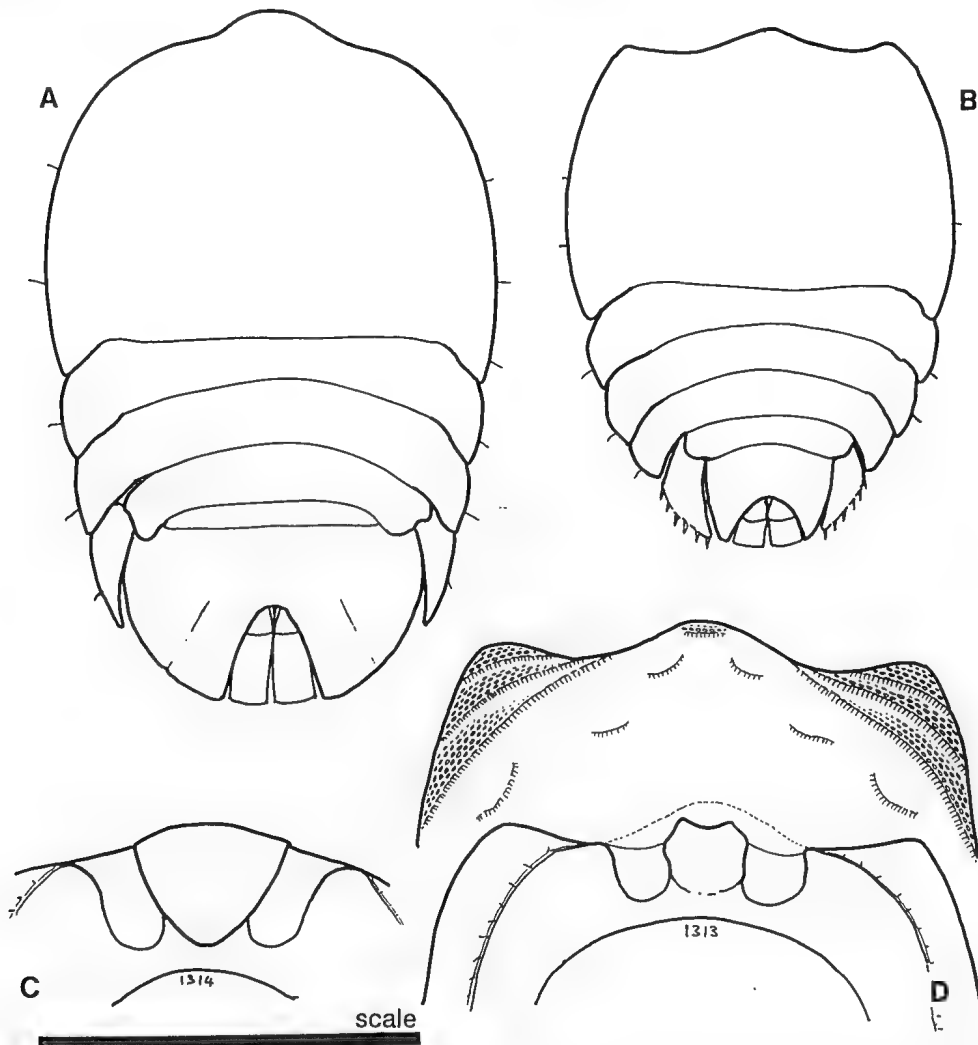


Fig. 6. *Tectacingulum nigrum*. A – adult female; B – adult male; C – female rostrum (ventral view); D – male anterior border of cephalosome and rostrum (dorsal and ventral view). Scale bar: A,B = 0.55 mm; C,D = 0.35 mm.

boulders encrusted with *Lithothamnion* and grazed by the sea urchin, *Centrostephanus rodgersii*, in the infralittoral fringe in a sheltered bay.

***Tectacingulum nigrum* n.sp.**

Figs 6-9

**Type material.** HOLOTYPE adult female with egg mass,

AM P42304; ALLOTYPE adult male, AM P42305; PARATYPES 2 adult females, 2 adult males, 3 copepodides, dissected female (slide 1314), dissected male (slide 1313). Paratype material held at ZANU, registration Po.W. [Mb.4] [total type population 4 females carrying eggs, 4 males (1 coupled to juvenile female)]. Collected from seaweed in infralittoral fringe on rocky shore, Merimbula Head, NSW (36°55'S 149°55'E), 2 Dec. 1982, V.A.P. Harris.

**Diagnosis.** Adult female. Indigo blue or black;

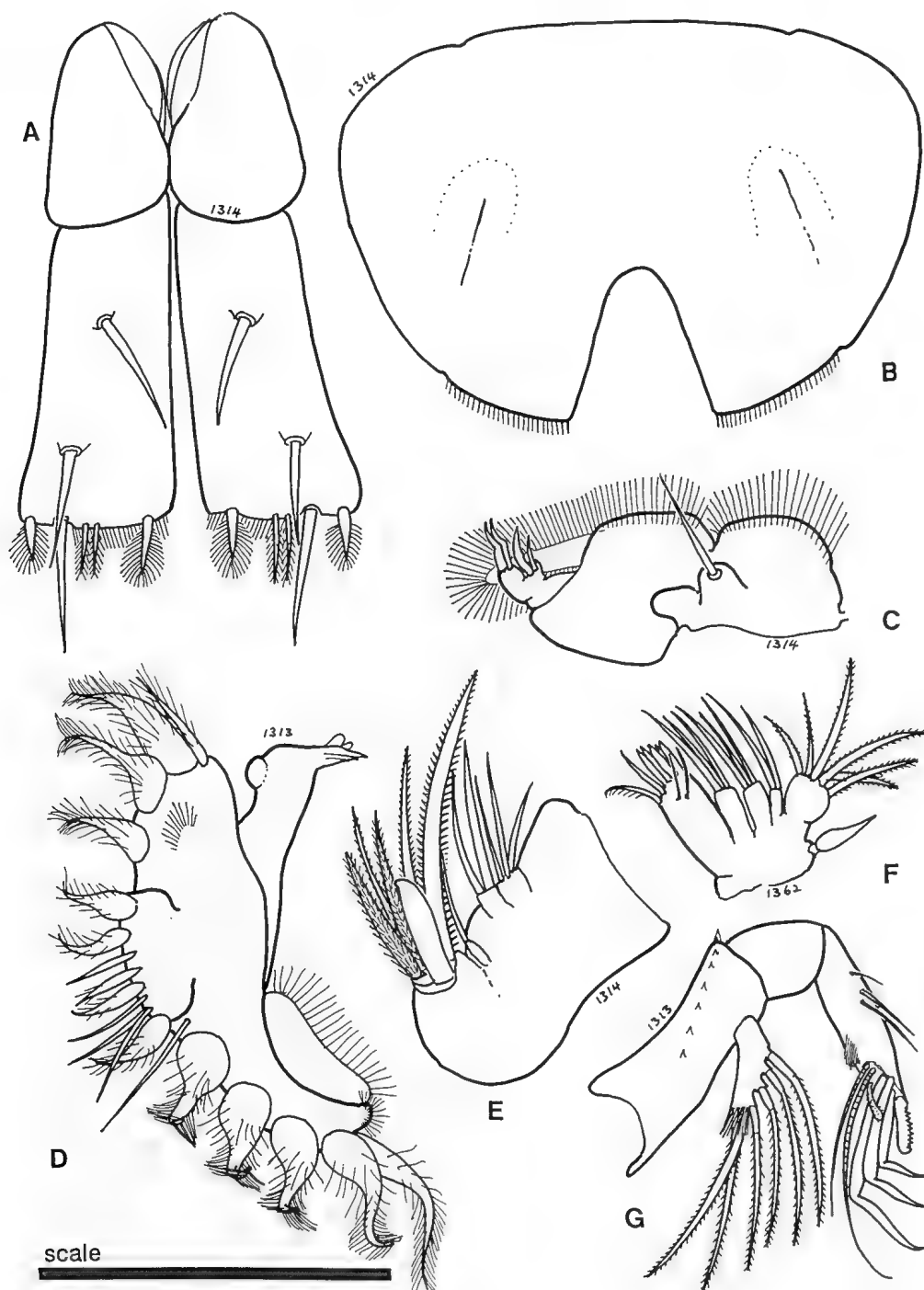


Fig. 7. *Tectacingulum nigrum*. A – female caudal rami; B – female urosome; C – maxilliped; D – male mandible; E – maxilla; F – maxillule; G – antenna. Scale bar: A,C,D,G = 0.12 mm; B = 0.26 mm; E,F = 0.1 mm.

cephalosome only slightly wider than metasome; length 0.9-1.0 mm; rostrum width 0.13 mm, not visible from above, ratio of cephalosome width to rostrum 4.7-5.0; dorsal surface conspicuously pitted, edge of cephalosome with striated false border; urosome broad, semicircular, caudal arch V-shaped, no notch, conspicuous colourless scar; caudal rami rectangular, widen distally, not emarginate,  $\beta$  seta midway between  $\alpha$  and  $\gamma$ , all terminal setae pinnate; large peg fields on endopod and exopod of P1; P5 short, reaches halfway down urosome.

**Adult male.** Indigo blue or black, anterior of cephalosome convex in midline, antennule sockets obscured, shoulders rounded, project forward with 'epaulet'; antennule with ventral blade.

**Dimensions. Females.** Length 0.92-0.98 mm (N = 4), cephalosome width 0.61-0.66 mm, height 0.14 mm, body length to width ratio 1.47-1.5. Rostrum 0.13 mm, ratio of cephalosome width to rostrum 4.7-5.0. Urosome width to length ratio 1.54. Caudal ramus length to width

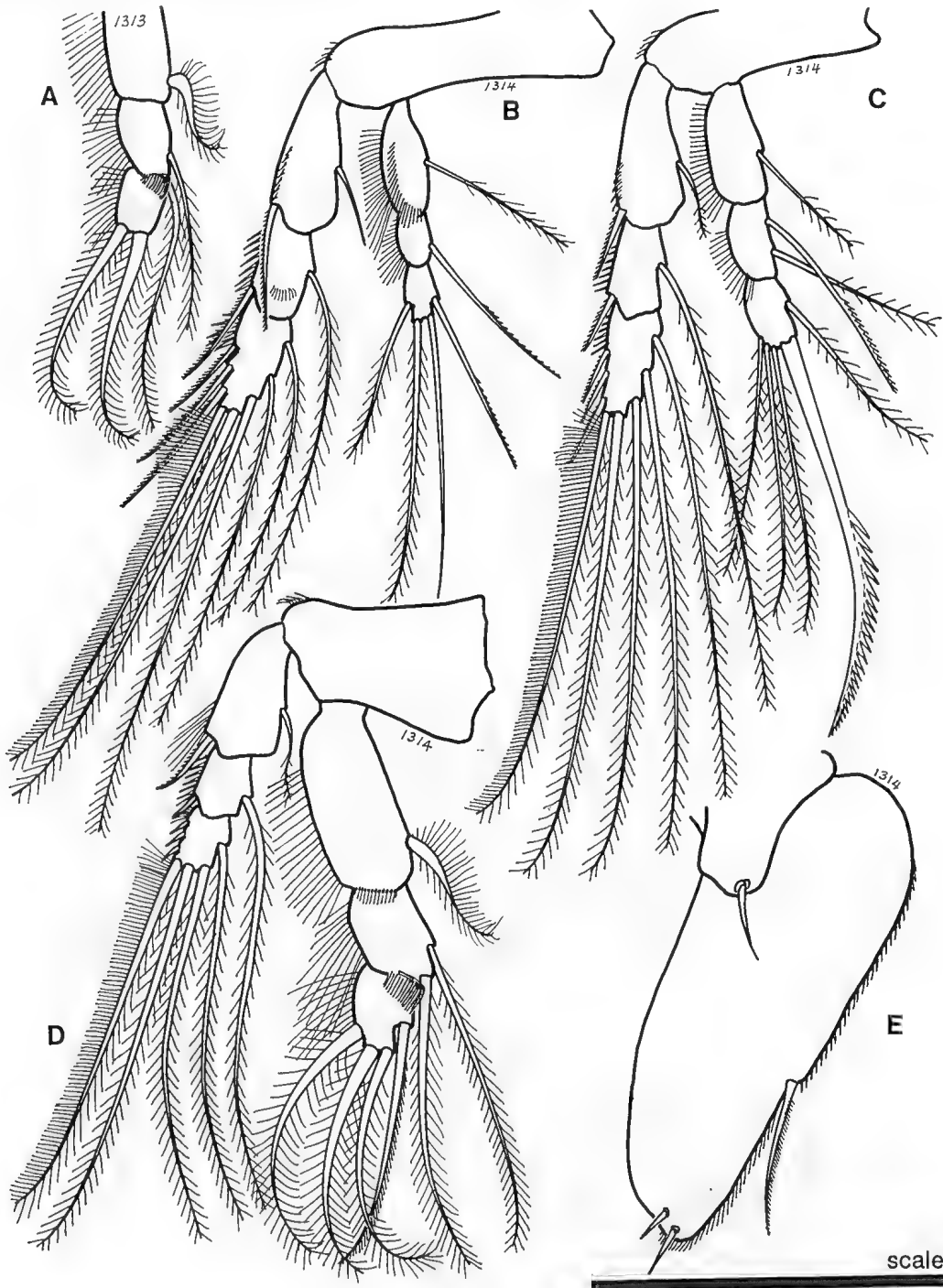


Fig. 8. *Tectacingulum nigrum*. A – male P2 endopod; B – P4; C – P3; D – female P2; E – female P5. Scale bar: A-D = 0.19 mm; E = 0.16 mm.



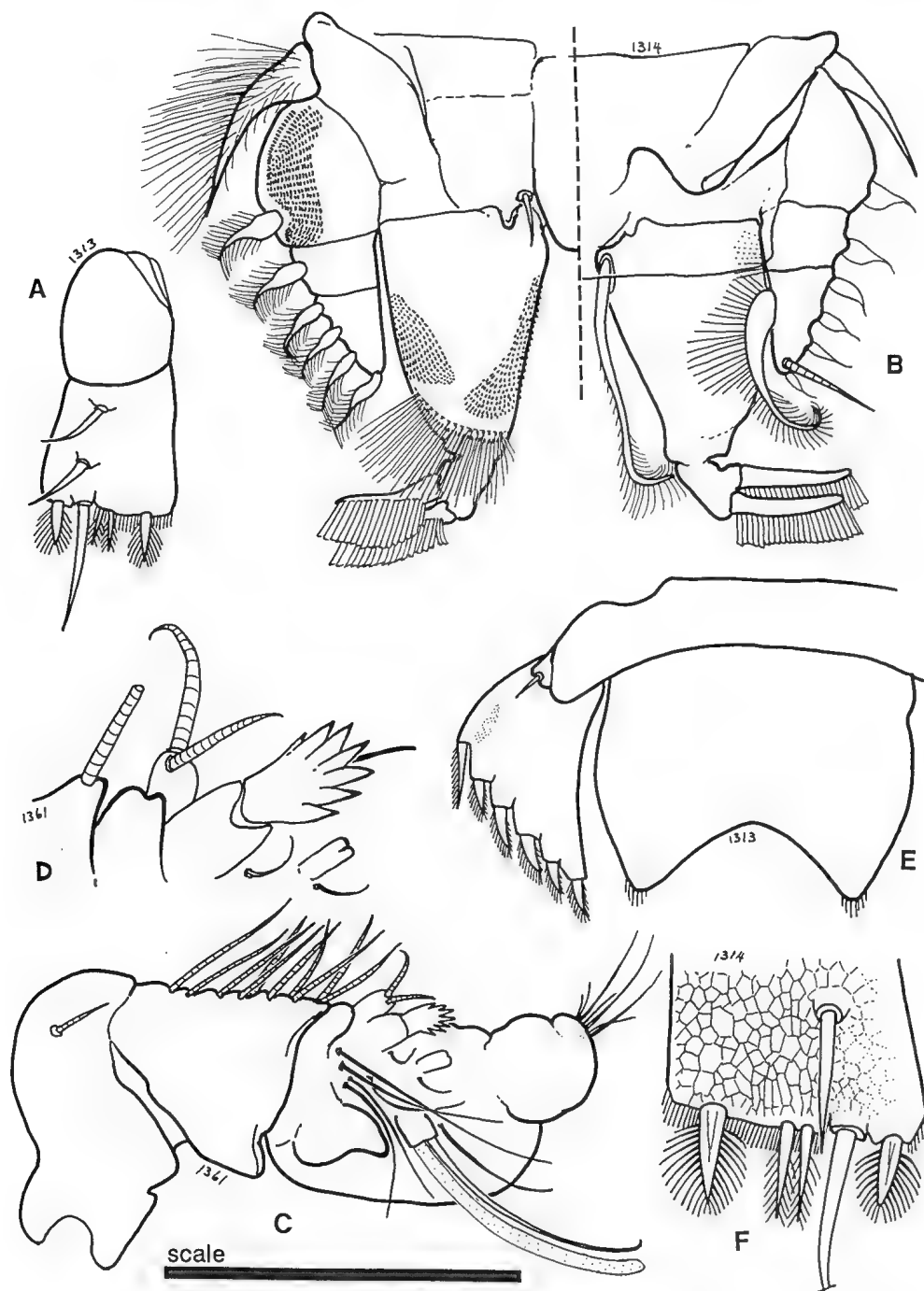
(maximum) ratio 2.0.

**Males.** Length 0.65-0.71 mm (N = 3), cephalosome length 0.4 mm, width 0.5-0.56 mm, ratio of body length to width 1.25-1.3.

**Adult female** (Fig. 6A). Anterior outline of cephalosome semicircular, lateral edge folded under ventrally, false border with radial striations (Fig. 2D). Hyaline border absent. Rostrum obscured from dorsal

view by medial bulge of cephalosome (Fig. 6C). Dorsal surface of cephalosome, metasome, urosome and caudal rami conspicuously pitted. Numerous sensory setae dorsally and at edge of cephalosome.

Urosome broad, semicircular in outline (Fig. 7B), lateral notch absent, conspicuous scar (colourless in live animal) indicating position of fused anterior and posterior lobe, posterior lobe bordered with fine setules. Caudal arch V-shaped, slightly less than half urosome



**Fig. 9.** *Tectacingulum nigrum*. A – left male caudal ramus; B – P1 (left ventral, right dorsal); C – male antennule (distal segment extended); D – detail of coupling denticles on male antennule; E – male urosome and P5; F – female caudal ramus showing detail of terminal setae. Scale bar: A,B = 0.12 mm; C = 0.1 mm; D not to scale; E = 0.19 mm; F = 0.075 mm.

length.

Caudal rami long rectangular, broaden distally (Fig. 7A), not emarginate.  $\alpha$  seta about one-third, and  $\beta$  seta three-quarters way down ramus; terminal setae all strongly pinnate, 1 and 4 thicker than 2 and 3, 4 set in from corner; terminal fringe of very fine setules present (Fig. 9F). Caudal rami do not project beyond caudal arch in natural position.

Limbs with typical setation (Figs 7-9). Spatulate claw on endopod of antenna pectinate, terminal portion of geniculate claws plain (Fig. 7G). Maxillule with 1 seta on exopod and 6 setae on endopod (Fig. 7F). Maxilla as shown in Figure 7E. Maxilliped medial lobe semicircular with fimbriate edge (Fig. 7C), basis with fimbriate edge and fimbriate process. First pereopod (P1, Fig. 9B) with very large field of denticulate pegs on article 1 of exopod, large triangular medial peg field plus large lateral peg field on endopod. Fimbriate crescent on endopod composed of 2 rows of filiform setules. Terminal article of P2 endopod with 1 serrulate spinous and 3 plumose setae (Fig. 8D). Serrate sabre-like seta of P3 endopod (Fig. 8C) considerably longer than endopod (1.5 : 1). External marginal setae of P4 exopod long (equal to length of individual articles), serrulate spinous setae on second and third articles of endopod (Fig. 8B). Distal article of P5 (Fig. 8E) lanceolate, apex obliquely truncated, rounded with 2 apical setae, lateral seta long; P5 short relative to urosome (Fig. 6A).

**Adult male** (Fig. 6B). Cephalosome truncated anteriorly, strongly convex in midline obscuring lateral angle of antennule socket, shoulders acutely rounded, project forward with conspicuous tangential rows of pits (Fig. 6D). Edge of cephalosome folded under as in female. Ornamentation of pits and sensory setae as for female.

Urosome (Fig. 9E) with no clear demarcation between anterior and posterior lobes, small group of setules at posterior apex, caudal arch shallow. Caudal rami quadrate, slightly wider distally (Fig. 9A); setation as for female.

Antennule prehensile (Fig. 9C); ventral blade short, coupling denticle palmate (Fig. 9D), terminal segment very short. First pilose seta of mandibular palp thin. P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 8A). P5 with 6 terminal setae as shown in Figure 9E.

**Remarks.** *Tectacingulum nigrum* is indigo blue or black with a red eye. The limbs and scar on the urosome are colourless, the latter appears as a white streak. Under certain light conditions parts of the body show an iridescent blue. This is the only black species described for the family (*L. nigra* = black).

*Tectacingulum nigrum* closely resembles *T. tumidum*, especially in the shape of urosome, setation of caudal rami and peg fields on P1, but the species are distinguished on colour, size, projection of rostrum, striated border to cephalosome, and body ratios.

**Distribution and abundance.** Only isolated specimens have been found, suggesting that the seaweed on which it normally lives has not been sampled or that it is a sublittoral species. The type material was collected at the one locality from various seaweeds (*Cystophora*, *Ecklonia*, *Phyllospora* and encrusted stones) on the same occasion. It has been recorded from Kioloa and Merimbula, NSW.

### *Murramia* n.gen.

**Diagnosis.** Anterior of female cephalosome semicircular, male only slightly truncated; hyaline border and dorsal pits present; urosome broad, with epimeral expansions to form anterior and posterior lobes, caudal rami included in caudal arch of urosome; caudal rami long rectangular not emarginate,  $\alpha$  and  $\beta$  setae not close together, terminal setae 2 and 3 slender, close together; maxillule endopod with 6 setae; maxilliped basis with fimbriate process, coxal lobe fimbriate; male P2 endopod with 3 terminal setae (1 serrulate spinose + 2 plumose); male P5 with 6 terminal setae; female P5 does not extend beyond the urosome or touch its fellow posteriorly.

**Species composition.** *Murramia magna* n.sp.; *M. bicincta* n.sp.

**Remarks.** This genus is characterised by the absence of a ventral blade on the male antennule and the presence of three terminal setae on the endopod of male P2. The generic name is taken from an aboriginal word, Murrami, meaning 'crayfish'.

The two species are known from Kioloa and the southern coast of New South Wales.

### *Murramia magna* n.sp.

Figs 10-14

**Type material.** HOLOTYPE adult female with egg-mass, AM P42306; ALLOTYPE adult male, AM P42307; PARATYPES 3 ovigerous females, 4 males, AM P42308; 15 females, 10 males [Br.21] designated paratypes BM(NH) 1992.536-560. Dissections from which illustrations were made have been designated paratype material (slides 1006, 1078, 1395 male, 1007 female); these and remaining type population held at ZANU, registration Po.Q [Br.71] [total type population 32 females (16 carrying eggs), 43 males (1 coupled to juvenile female)]. Taken from *Ecklonia radiata* in the infralittoral fringe at edge of Broulee rock platform, Broulee, NSW (35°52'S 150°11'E), 21 Jan. 1977, V.A.P. Harris.

**Diagnosis.** Adult female. Orange-brown; mean length 1.37 mm, rostrum width 0.26 mm, ratio of cephalosome width to rostrum 3.4; dorsal surface conspicuously pitted; anterior and posterior lobes of urosome equal in length, small lateral notch with scar, no cleft, caudal

arch deep; caudal rami long rectangular, slightly emarginate, 3 seta near posterior border, terminal seta 1 unipinnate, 2 and 3 plain close together, 4 set in from medial corner; small peg field on endopod of P1.

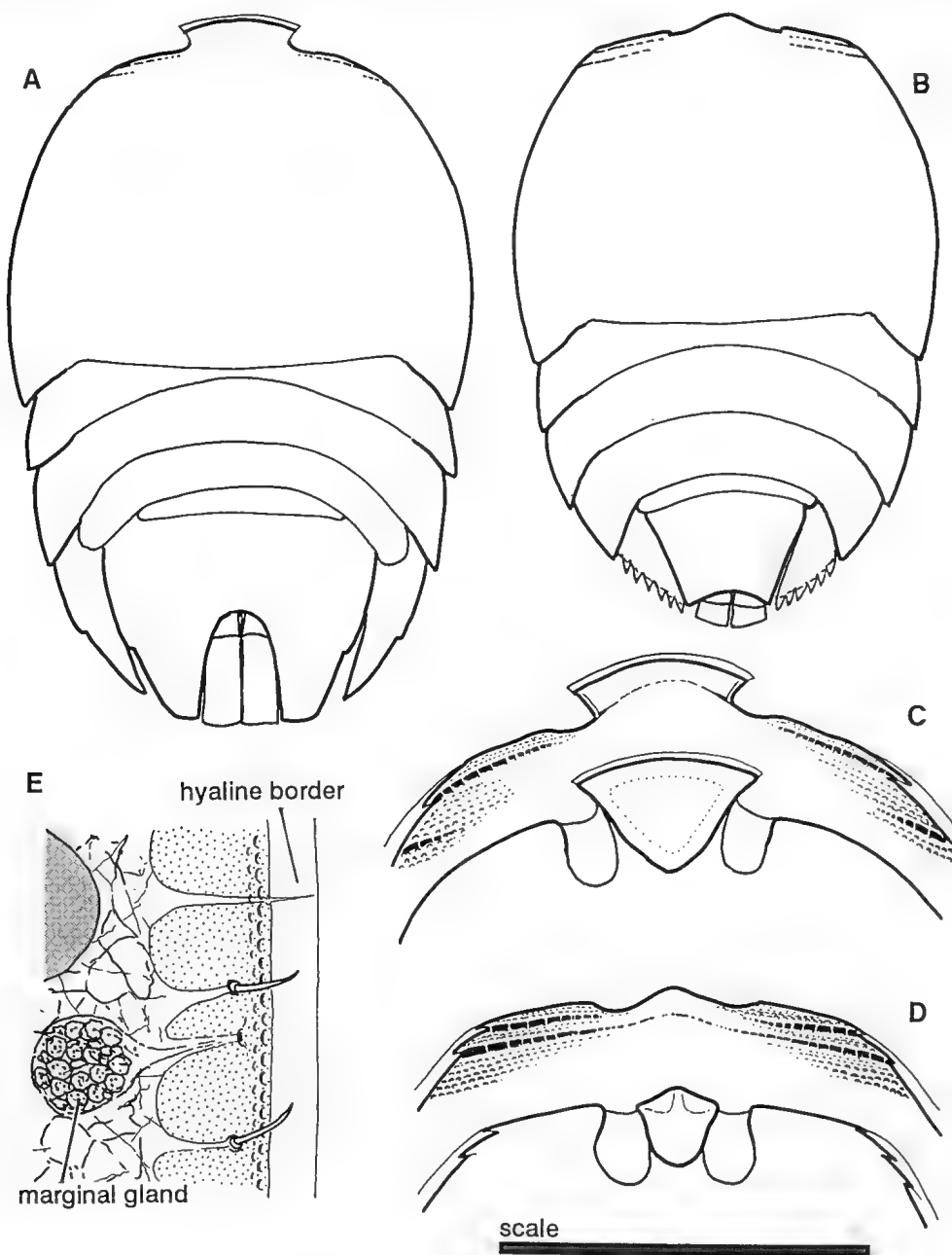
**Adult male.** Antennule socket obscured, shoulders rounded; no ventral blade on antennule.

**Dimensions. Females.** Mean length 1.38 mm (SD = 0.026, N = 15), cephalosome length 0.9 mm, width 0.9 mm (SD = 0.018), height 0.2 mm, body length to width ratio 1.53. Rostrum 0.26 mm wide, projects 0.08 mm, ratio of body width to rostrum 3.46. Urosome width

to length ratio 1.3. Caudal ramus length to width ratio 2.75.

**Males.** Mean length 1.21 mm (SD = 0.022, N = 15), Cephalosome length 0.7 mm, width 0.86 mm (SD = 0.019), body length to width ratio 1.4.

**Adult female (Fig. 10A).** Anterior outline of cephalosome semicircular. Rostrum prominent, convex with hyaline edge (Fig. 10C). Hyaline border of cephalosome and epimeral lobes 15–17  $\mu$ m wide, marginal glands open just dorsal to hyaline border (Fig. 10E). Dorsal surface of cephalosome, epimera, urosome, P5



**Fig. 10.** *Murramia magna*. A – adult female; B – adult male; C – female rostrum (dorsal and ventral views); D – male anterior border of cephalosome and rostrum (dorsal and ventral views); E – hyaline fringe of cephalosome showing dorsal opening of marginal glands. Scale bar: A,B = 0.72 mm; C,D = 0.55 mm; E = 0.1 mm.

and caudal rami conspicuously pitted, pits 3-5  $\mu\text{m}$  with raised crescentic edge.

Urosome (Fig. 11B) resembling a truncated triangle with almost straight sides, fine setules along posterior border of posterior lobe, small lateral notch and scar, caudal arch very deep (almost half length of urosome).

Caudal ramus (Fig. 11A) elongate rectangular, slightly wider posteriorly, medial and lateral edges straight, external corner slightly emarginate.  $\alpha$  seta quarter way

down ramus,  $\beta$  seta close to posterior border; terminal seta 1 unipinnate, 2 and 3 plain, close together, 4 plain, set in from medial corner; terminal fringe of fine setules present (Fig. 11C).

Limbs (Figs 11-13) with typical setation. Antennule as shown in Figure 14D. Antenna (Fig. 13B) with pectinate spatulate claw on endopod, terminal portions of geniculate claws plain. Maxillule with single seta on exopod, 6 setae on endopod and 4 setae on each of the 3 endites, gnathobase bears 2 geniculate setae,

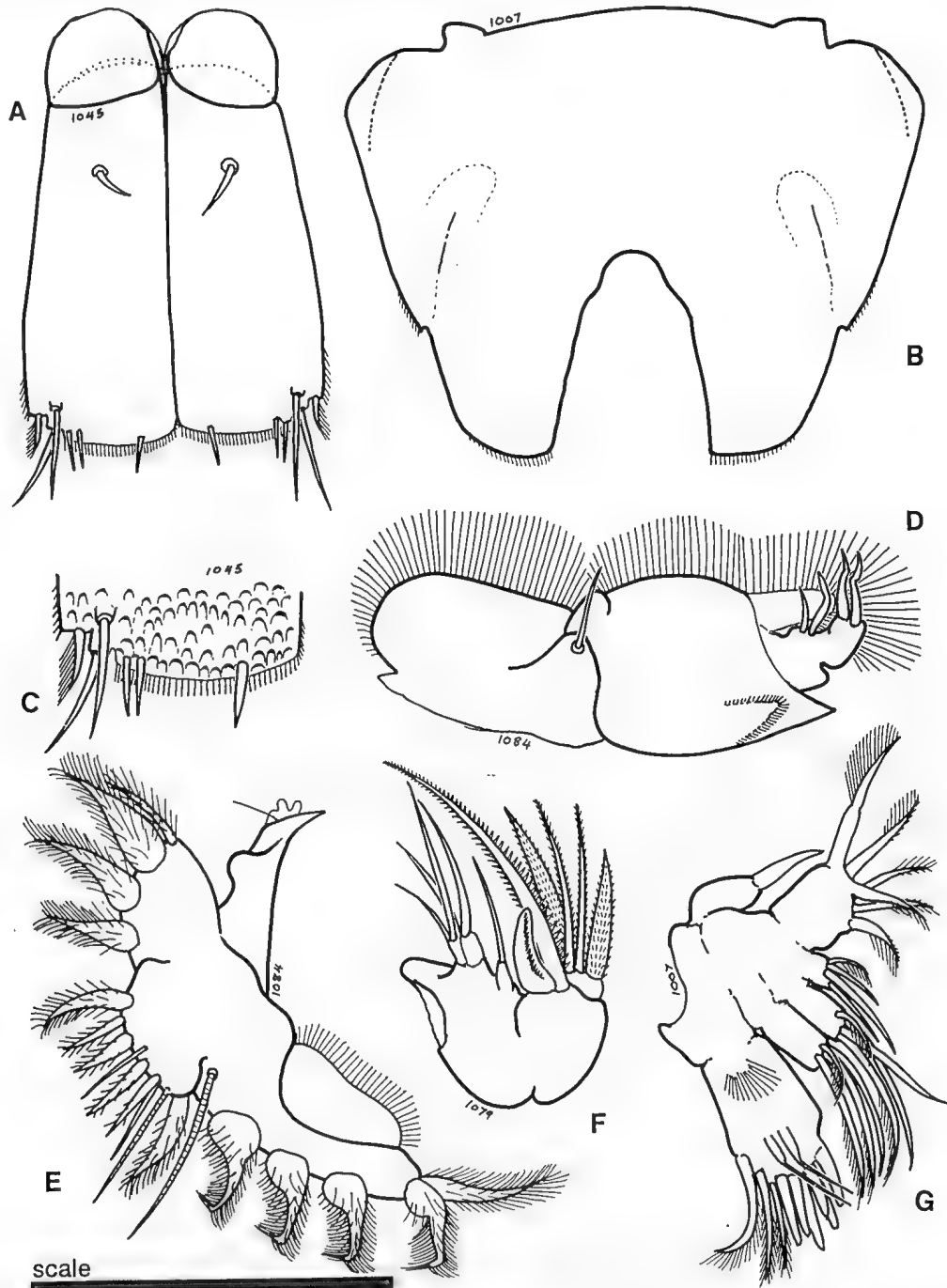


Fig. 11. *Murramia magna*. A – female caudal rami; B – female urosome; C – female caudal ramus showing detail of terminal setae; D – maxilliped; E – male mandible; F – maxilla; G – maxillule. Scale bar: A, F = 0.16 mm; B = 0.35 mm; C, G = 0.1 mm; D = 0.12 mm; E = 0.22 mm.

3 pinnate and 6 stout plain setae (Fig. 11G). Maxilla as shown in Figure 11F. Semicircular medial lobe of maxilliped with fimbriate border, basis elongate with fimbriate border, oblong fimbriate process and >-shaped group of setules (Fig. 11D). First peraeopod (P1, Fig. 12A) with crescentic field of denticulate pegs on article 1 of exopod; fimbriate crescent on endopod ends laterally in small oval denticulate peg field. P2 endopod with 1 serrulate spinous seta and 3 plumose setae on terminal article (Fig. 13A). Serrate sabre-like

seta on article 3 of P3 endopod slightly longer than endopod (1.1 : 1) (Fig. 13D). P4 with 2 serrulate spinous setae on endopod (Fig. 12C). Distal article of P5 lanceolate with strong falciform ventral ridge, 1 dorsal and 2 apical setae (Fig. 12E). Apex of P5 reaches as far as lateral notch of urosome.

**Adult male** (Fig. 10B). Anterior outline of cephalosome not sharply truncated, obtusely pointed in midline, antennule socket obscured, shoulders broadly rounded

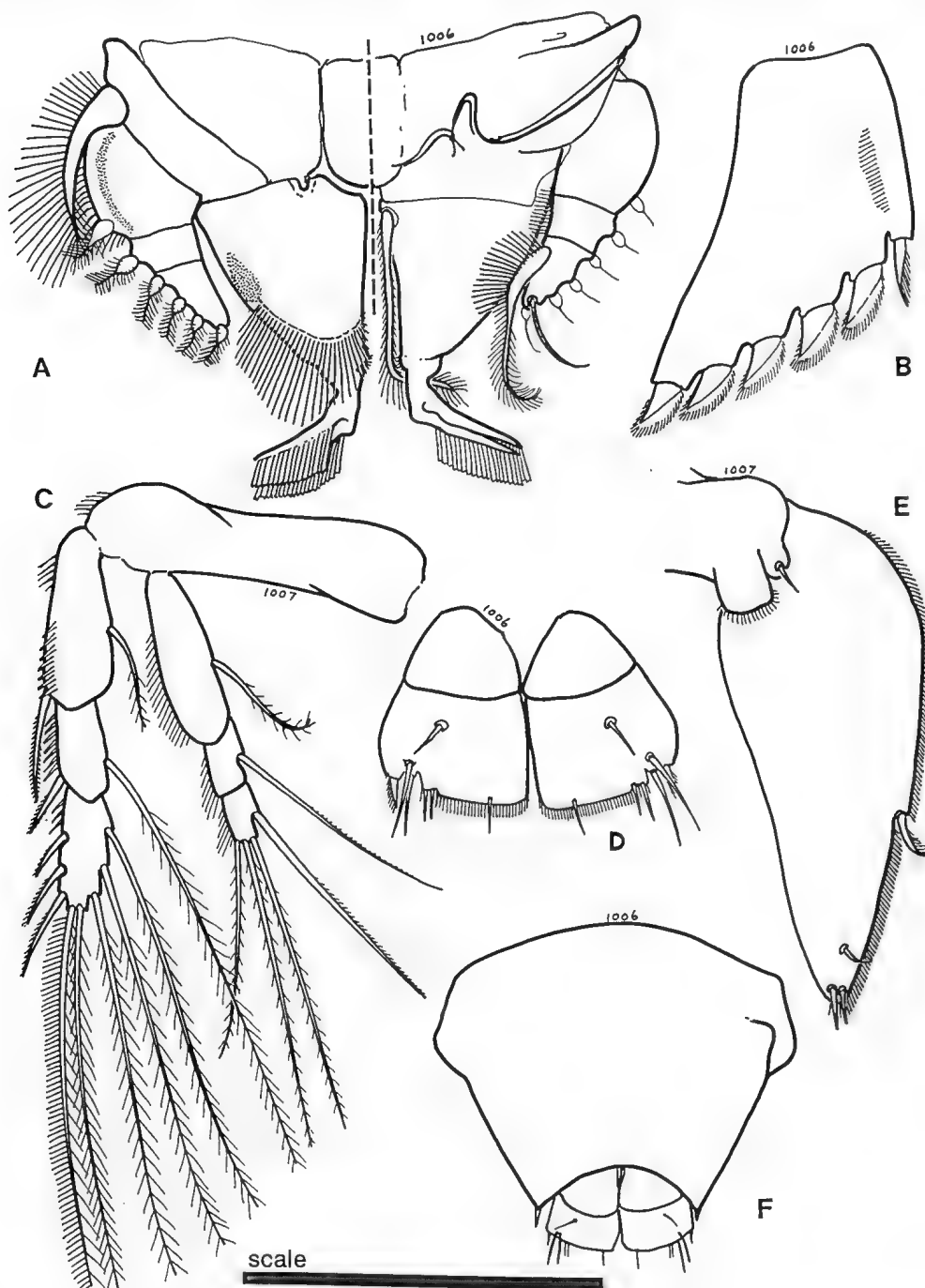


Fig. 12. *Murramia magna*. A – P1 (left ventral, right dorsal); B – male P5; C – P4; D – male caudal rami; E – female P5; F – male urosome. Scale bar: A,E = 0.26 mm; B,D = 0.19 mm; C = 0.22 mm; F = 0.35 mm.

(Fig. 10D). Hyaline border and dorsal pits as for female.

Urosome (Fig. 12F) with single apical setule. Caudal rami short (length to width ratio 0.7), setation as for female (Fig. 12D).

Antennule (Fig. 14B) prehensile; small denticulate tubercle on accessory lobe, no ventral blade; coupling denticles (Fig. 14A), large oval proximal denticle covered with pegs, small medial and distal denticles with serrated edges; prehensile terminal segment as long as compound segment. P1, P3 and P4 as for female. P2 with 1 serrulate spinous seta and 2 plumose setae on

distal article of endopod (Fig. 13C). First terminal seta on P5 slender unipinnate, remaining 5 setae deltoid with pinnate lateral border (Fig. 12B).

**Remarks.** *Murramia magna* is the largest species within the family described to date, hence the trivial name (*L. magna* = great). The orange-brown colour of adults matches their seaweed substratum.

**Distribution and abundance.** Populations of this species have been recorded only from Broulee, NSW

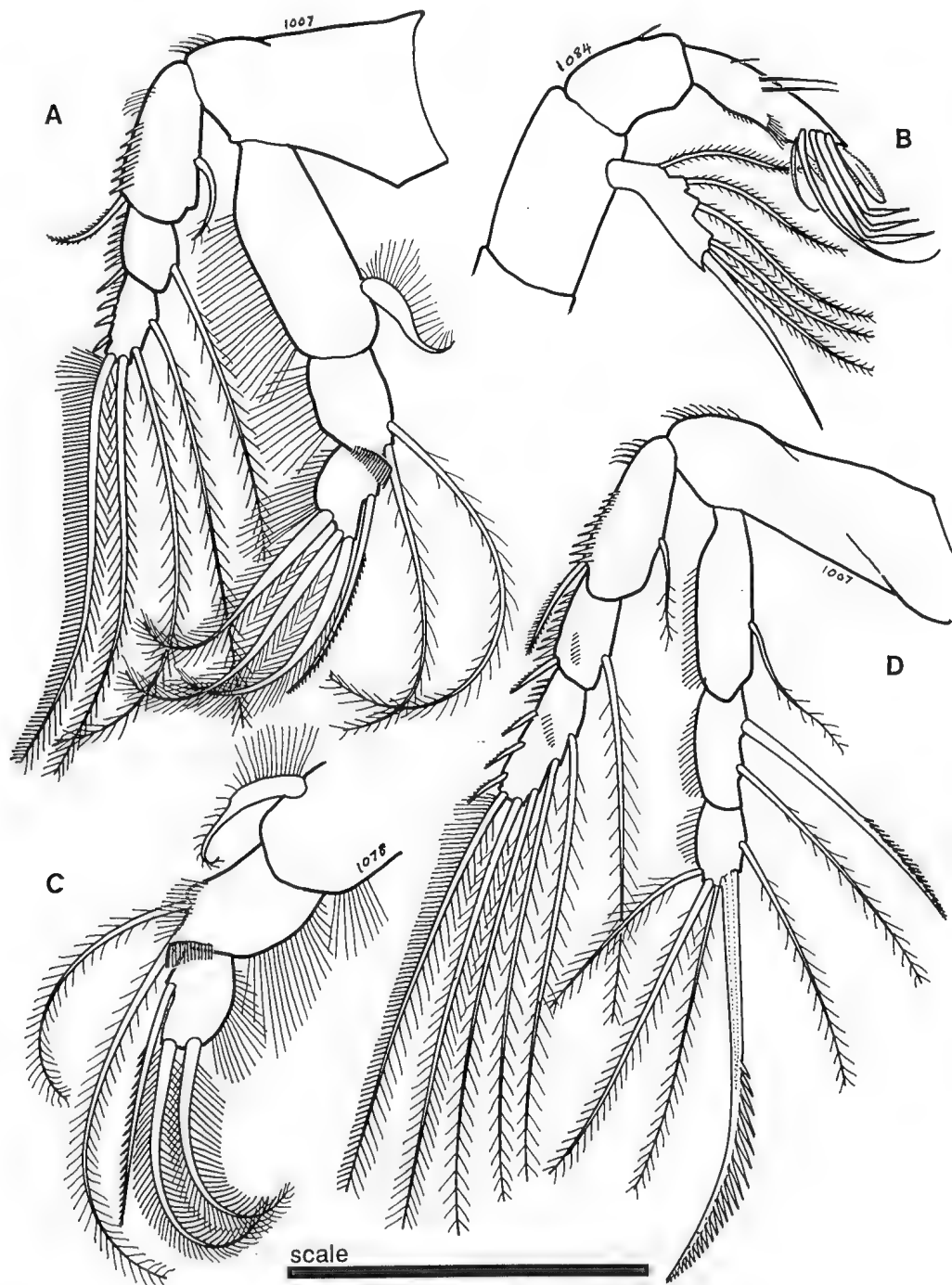


Fig. 13. *Murramia magna*. A – female P2; B – antenna; C – male P2 endopod; D – P3. Scale bar: A,D = 0.22 mm; B,C = 0.19 mm.

although two specimens were collected on *Ecklonia* at Twofold Bay, Eden, NSW. It invariably occurs on *Ecklonia radiata* where modest populations (50-100) are not uncommon.

*Murramia bicincta* n.sp.

Figs 15-18

**Type material.** HOLOTYPE adult female with egg-mass, AM P42309; ALLOTYPE adult male, AM P42310; PARATYPES 2 females, 2 males, AM P42311; 3 females, 2 males [Ki.55, Br.85] designated paratypes, BM(NH) 1992.523-527. Dissections from which illustrations were made have been designated paratype material (slides 1326 female, 1327, 1358 male), remaining type population held at ZANU, registration Po.S. [Ki.40] [total type population 11 females (7 carrying eggs), 18 males plus 1 male coupled to juvenile]. Washed from *Cystophora* sp., north side of O'Hara Head, Kioloa, NSW (35°30'S 150°22'E), 19 Jan. 1977, V.A.P. Harris.

**Diagnosis.** *Adult female.* Yellow with 2 brown transverse bands; mean length 1.07 mm; rostrum width

0.18 mm, ratio of cephalosome width to rostrum 3.67; dorsal pits not conspicuous; urosome broad with scar and notch, posterior lobe large, caudal arch deep; caudal rami rectangular, not emarginate,  $\beta$  seta near posterior border, terminal 1 seta unipinnate, 2 and 3 plain, slender, 4 set in from medial corner; small peg field on P1 endopod.

*Adult male.* Antennule socket just visible, shoulders rounded; no ventral blade on antennule.

**Dimensions.** *Females.* Mean length 1.07 mm (SD = 0.039, N = 10), cephalosome width 0.67 (SD = 0.020), height 0.16 mm, body length to width ratio 1.6, rostrum width 0.18 mm, ratio of cephalosome width to rostrum 3.7. Urosome width to length ratio 1.5. Caudal ramus length to width ratio 2.0.

*Males.* Mean length 0.86 mm (SD = 0.017, N = 11), cephalosome length 0.47 mm, width 0.6 mm (SD = 0.011), ratio of body length to width 1.4.

**Adult female** (Fig. 15A). Anterior outline of cephalosome semicircular with 2 ridges parallel to edge which end laterally where hyaline border begins

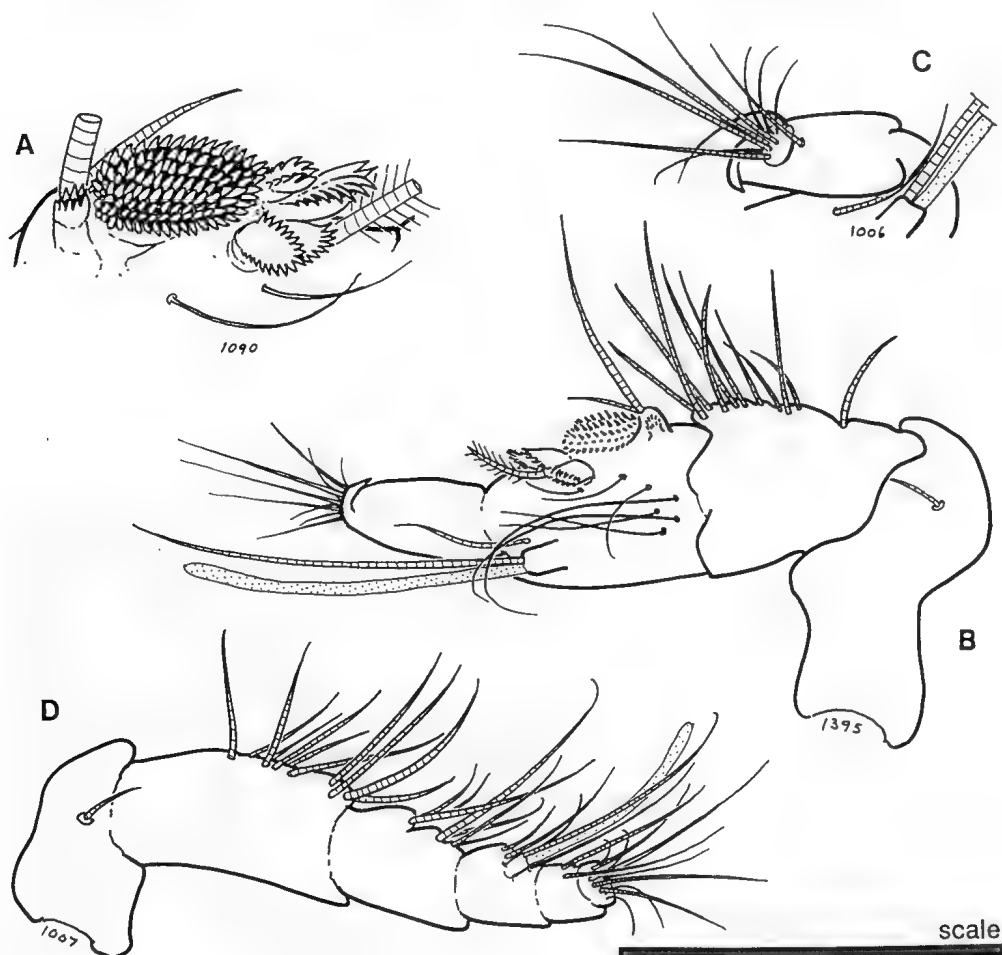


Fig. 14. *Murramia magna*. A – detail of coupling denticles on male antennule; B – male antennule with terminal segment extended (ventral view); C – same, with distal segment adducted; D – female antennule. Scale bar: A not to scale; B,C,D = 0.16 mm.



(Fig. 15C). Rostrum prominent, projects by about one-third of its width, with narrow hyaline border. Hyaline border of cephalosoma and epimeral lobes 10  $\mu\text{m}$  wide. Dorsal surface pitted with rows of pits along anterior ridges.

Urosome broad (Fig. 16B), edge of anterior lobe straight, posterior lobe large, rounded, medial corner not rounded, notch and prominent scar between lobes, border setules fine, short. Caudal arch deep (about half

urosoma length).

Caudal rami (Fig. 15E) long, rectangular, sides straight, slightly broader distally, slightly emarginate. Beta seta close to posterior border, terminal seta 1 unipinnate, 2 and 3 plain close together, 4 plain, set in from medial corner; terminal fringe of fine setules present (Fig. 18C). Caudal rami do not project beyond caudal arch in natural position.

Limbs (Figs 16-18) with typical setation. Spatulate

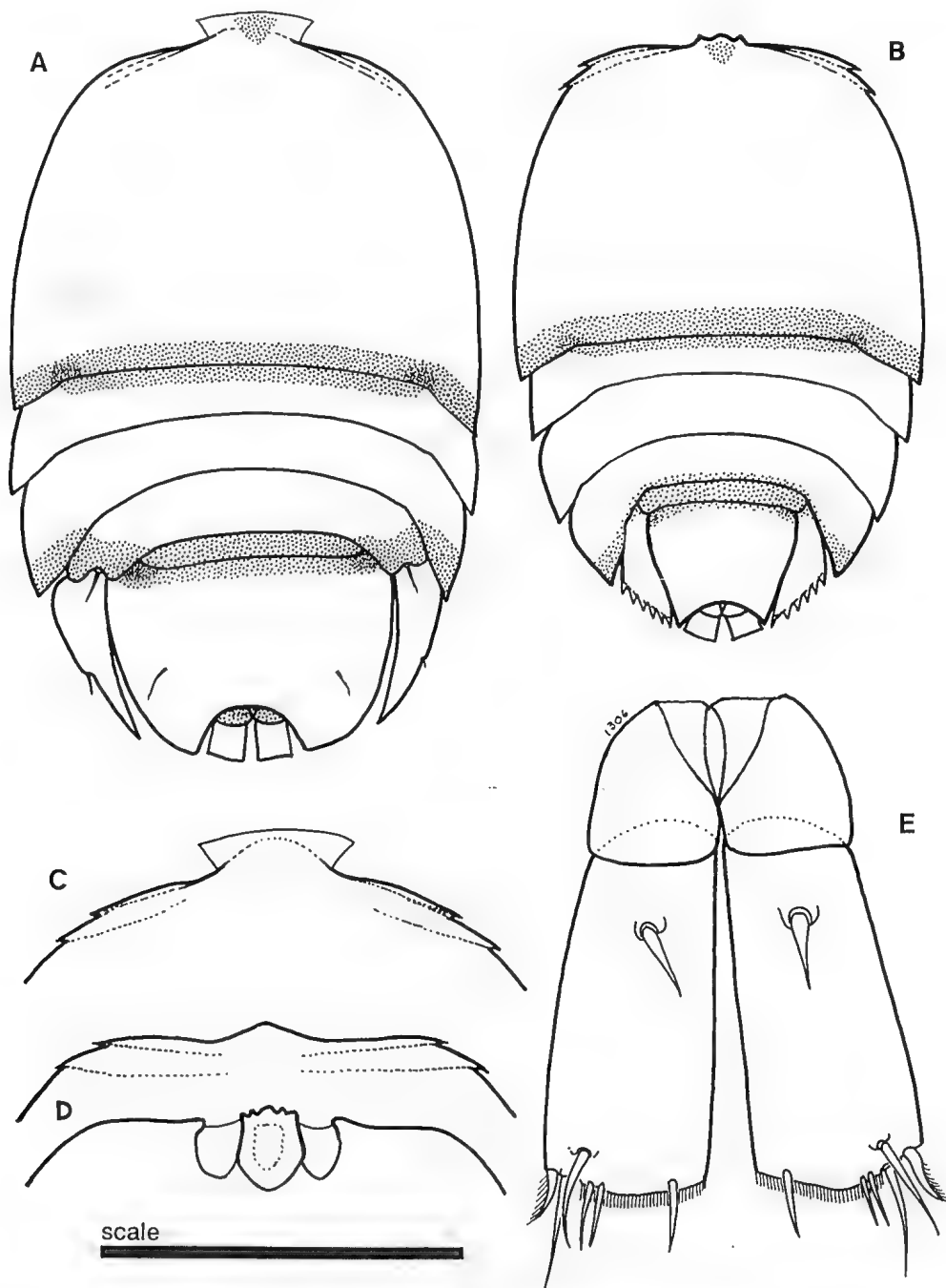


Fig. 15. *Murramia bicincta*. A – adult female, stippling represents brown colouration; B – adult male; C – female rostrum and anterior border of cephalosoma (dorsal view); D – male rostrum and anterior border of cephalosoma (dorsal and ventral views); E – female caudal rami and anal segment. Scale bar: A,B = 0.55 mm; C,D = 0.45 mm; E = 0.12 mm.

claw of antenna pectinate, geniculate setae articulated (Fig. 16A). Mandible as shown in Figure 16F. Maxillule with single seta on exopod, 6 setae on endopod, 4 setae on each of the endites (Fig. 16G). Maxilla as shown in Figure 16D. Maxilliped (Fig. 16H) with fimbriate rounded medial lobe, basis with fimbriate border continued as fimbriate process. First peraeopod (P1, Fig. 18B) with band of fine denticulate pegs on article

1 of exopod, small oval field of fine pegs at lateral extremity of fimbriate crescent on endopod. P2 with 1 serrulate and 3 plumose setae on terminal article of endopod (Fig. 17C). Serrate sabre-like seta on P3 endopod (Fig. 17B) slightly longer than endopod (1.2 : 1). P4 endopod with 2 spinous setae. Apex of P5 rounded with 1 dorsal and 2 apical setae, edge bordered with fine setules (Fig. 16E). P5 reaches as far as notch

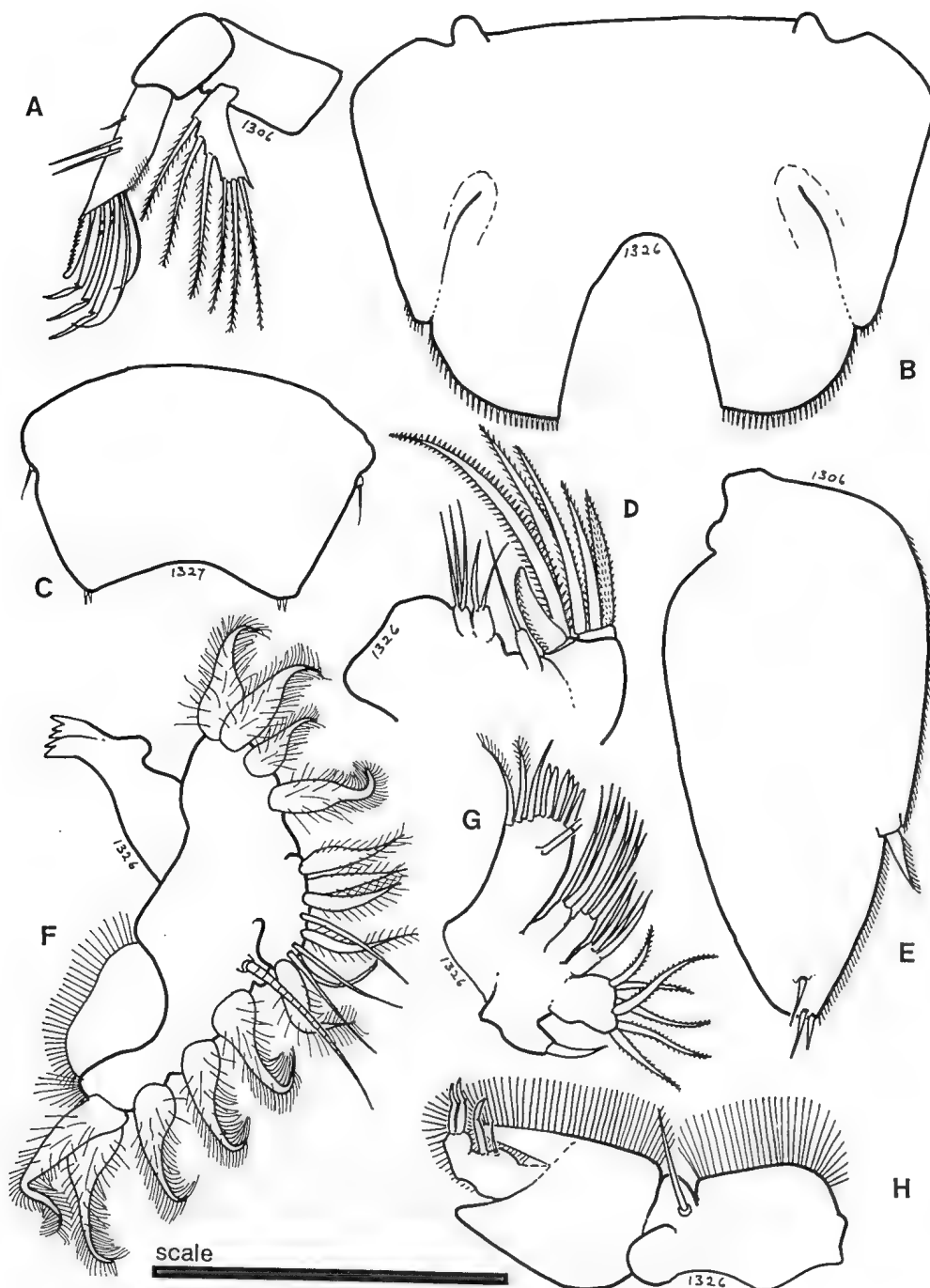


Fig. 16. *Murramia bicincta*. A – antenna; B – female urosome; C – male urosome; D – maxilla; E – female P5 (detached, dorsal view); F – female mandible (ventral view); G – maxillule; H – maxilliped. Scale bar: A = 0.19 mm; B,C = 0.26 mm; D,E,F,H = 0.16 mm; G = 0.1 mm.

on urosome.

**Adult male (Fig. 15B).** Anterior outline of cephalosome not markedly truncated, slightly bowed forward in mid-line, lateral angle of antennule socket just visible from dorsal view, shoulders rounded (Fig. 15D). Hyaline border and dorsal pits as for female.

Urosome as shown in Figure 16C. Caudal rami shorter than their width, setation as for female (Fig. 18A).

Antennules prehensile (Fig. 18E); accessory lobe of compound segment with small denticulate tubercle but no ventral blade. proximal coupling denticle large, oval in shape, covered with denticulate pegs, medial and distal denticles with serrated edges (Fig. 18F); prehensile terminal segment half length of compound segment, expanded distally. First seta on mandibular palp slender (Fig. 18D). P1, P3 and P4 as for female. P2 bears 3 setae on terminal article of endopod (1 serrulate spinous

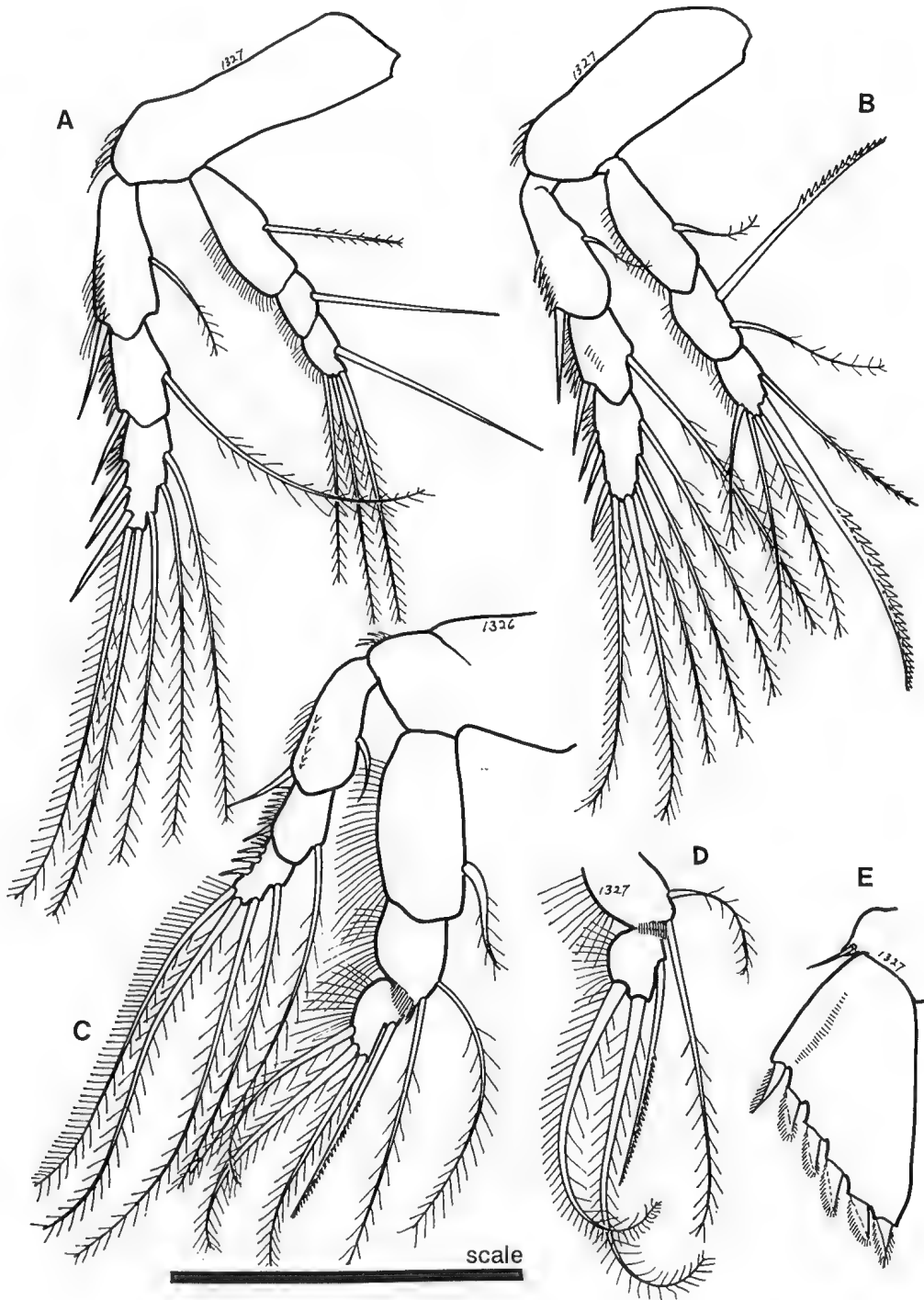


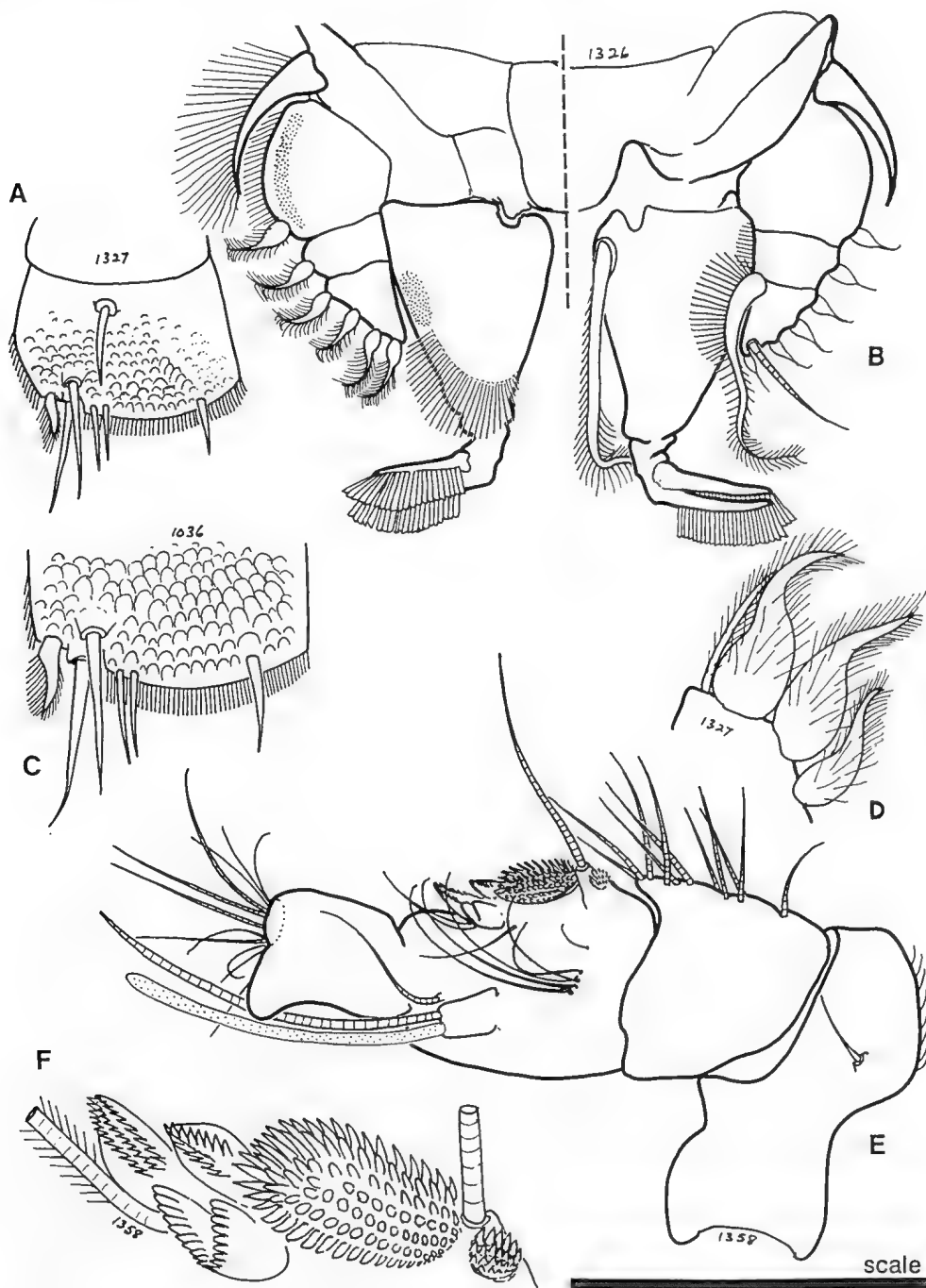
Fig. 17. *Murramia bicincta*. A - P4; B - P3; C - female P2; D - male P2 endopod; E - male P5. Scale bar: A,B,C,E = 0.19 mm; D = 0.16 mm.

seta plus 2 short plumose setae (Fig. 17D). P5 (Fig. 17E) triangular with 6 unipinnate deltoid terminal setae.

**Remarks.** The colour pattern of this species is distinctive. Living animals are yellow with reddish brown antennae, rostrum and anal segments. Two conspicuous bands of the same colour run across the body at the joint between cephalosome and first metasomal segment, and between the third metasomal

segment and urosome (see Fig. 15A,B). The specific name refers to this pattern (*L. bi* = two + *cinctus* = a belt or girdle).

**Distribution and abundance.** *Murramia bicincta* has been found only at Kioloa and Broulee, NSW living on *Cystophora moniliformis* and *C. platylobium* in the infralittoral fringe. Population samples have been small (10 - 30).

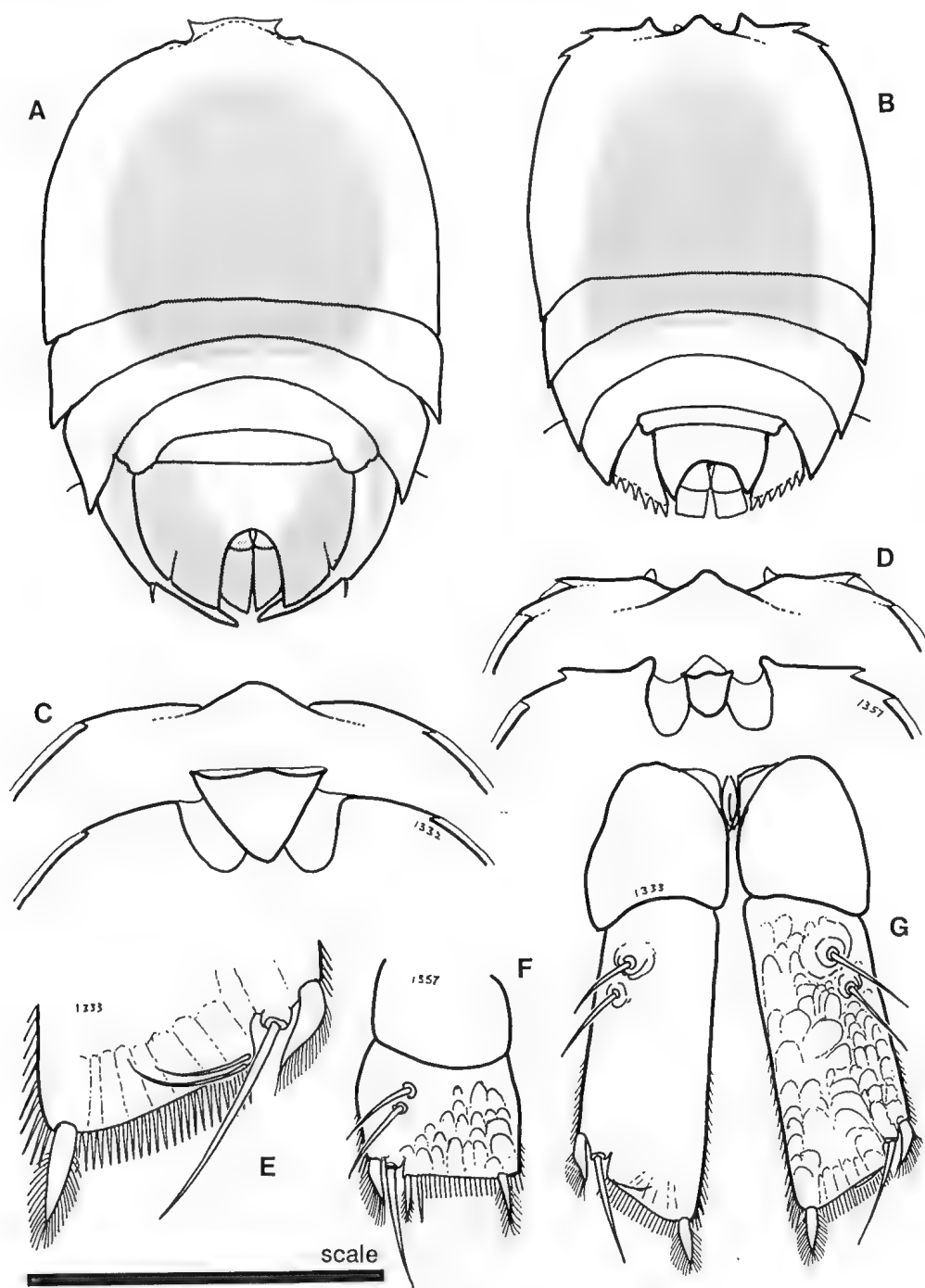


**Fig. 18.** *Murramia bicincta*. A – male left caudal ramus; B – P1 (left ventral, right dorsal); C – terminal edge of female left caudal ramus; D – male anterior mandibular palp; E – male antennule with terminal segment extended (ventral view); F – detail of coupling denticles. Scale bar: A = 0.1 mm; B = 0.19 mm; C = 0.075 mm; D and F not to scale; E = 0.12 mm.

*Kioloaria* n.gen.

**Diagnosis.** Anterior of female cephalosome semicircular, male truncated; hyaline border and dorsal pits present; urosome broad, with epimeral expansions to form anterior and posterior lobes, caudal rami included in caudal arch of urosome; caudal rami rhomboidal with oblique posterior border,  $\alpha$  and  $\beta$

setae close together, terminal seta 4 large, apical, 2 and 3 slender, close together; maxillule endopod with 6 setae; maxilliped basis with fimbriate process, coxal lobe fimbriate; male P2 endopod with 3 terminal setae (1 serrulate spinose + 2 plumose); male P5 with 6 terminal setae; female P5 extends beyond urosome and caudal rami, may touch its fellow posteriorly.



**Fig. 19.** *Kioloaria sesquimaculata*. A – adult female, shading indicates carmine red colour pattern; B – adult male; C – female rostrum (dorsal and ventral view); D – male anterior border of cephalosome (dorsal and ventral view); E – female detail of terminal setae on caudal ramus; F – male left caudal ramus; G – female caudal rami and anal segment. Scale bar: A,B = 0.45 mm; C,D = 0.33 mm; E = 0.055 mm; F = 0.1 mm; G = 0.12 mm.

**Species composition.** *Kioloaria sesquimaculata* n.sp.

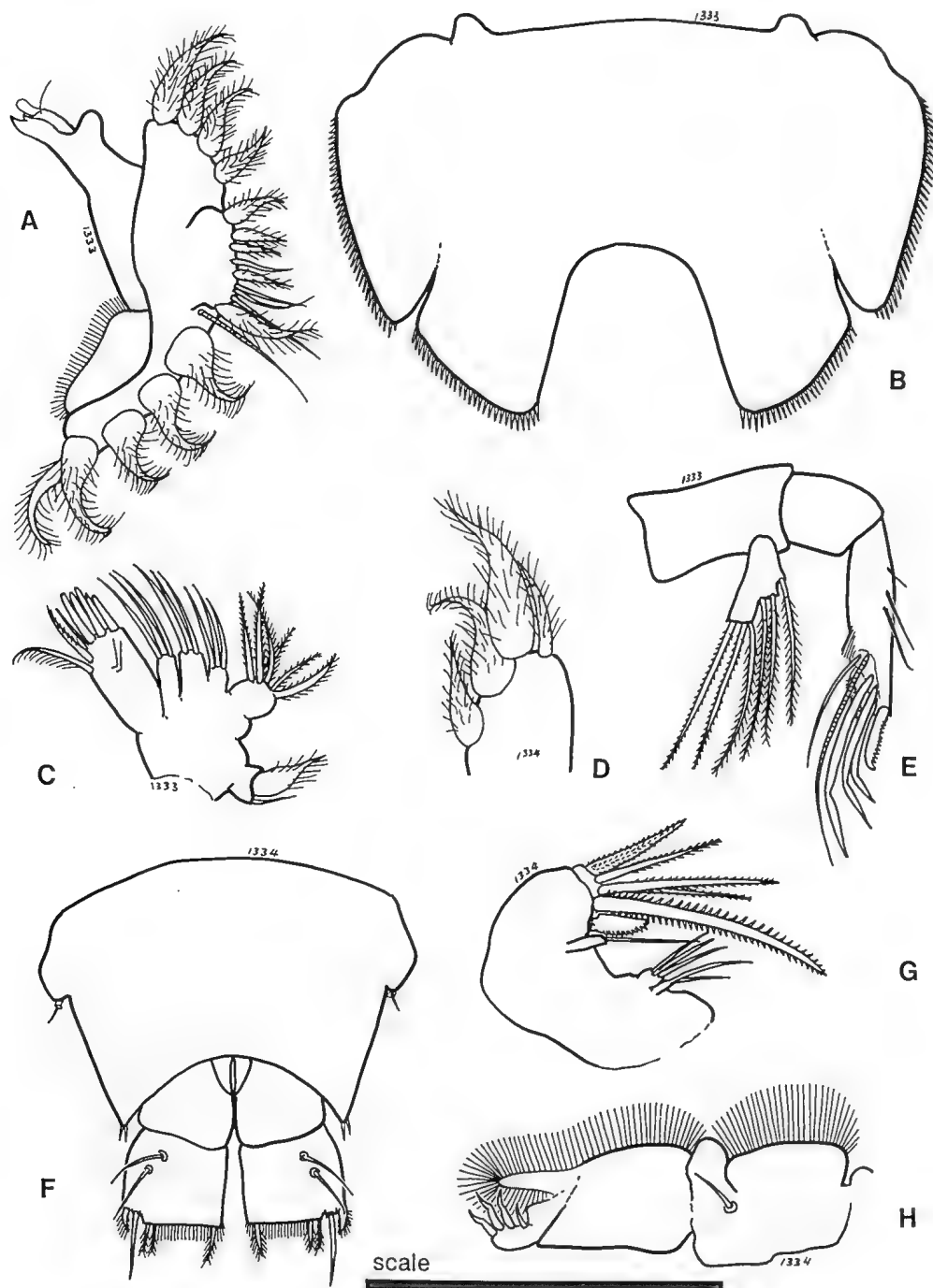
*Kioloaria sesquimaculata* n.sp.

Figs 19-22

**Remarks.** The rhomboidal caudal rami and the long P5 which meets its fellow posteriorly resemble *Acutiramus*, but *Kioloaria* is distinguished by having three setae on the terminal article of the male P2 endopod.

The genus has been named form the locality of the type species.

**Type material.** HOLOTYPE adult female with egg mass, AM P42312; ALLOTYPE adult male, AM P42313; PARATYPES 1 female, 1 male AM P42314; 4 females, 2 males [Ki.54] designated paratypes BM(NH) 1992.528-533. Dissected paratypes from which illustrations were made (slides 1333 female, 1334 male) together with remaining type population held at ZANU, registration Po.Y. [Ki.35] [total type population



**Fig. 20.** *Kioloaria sesquimaculata*. A – female mandible; B – female urosome; C – maxillule; D – male anterior mandibular palp; E – antenna; F – male urosome and caudal rami; G – maxilla; H – maxilliped. Scale bar: A,F = 0.165 mm; B = 0.19 mm; C,D,G,H = 0.1 mm; E = 0.12 mm.

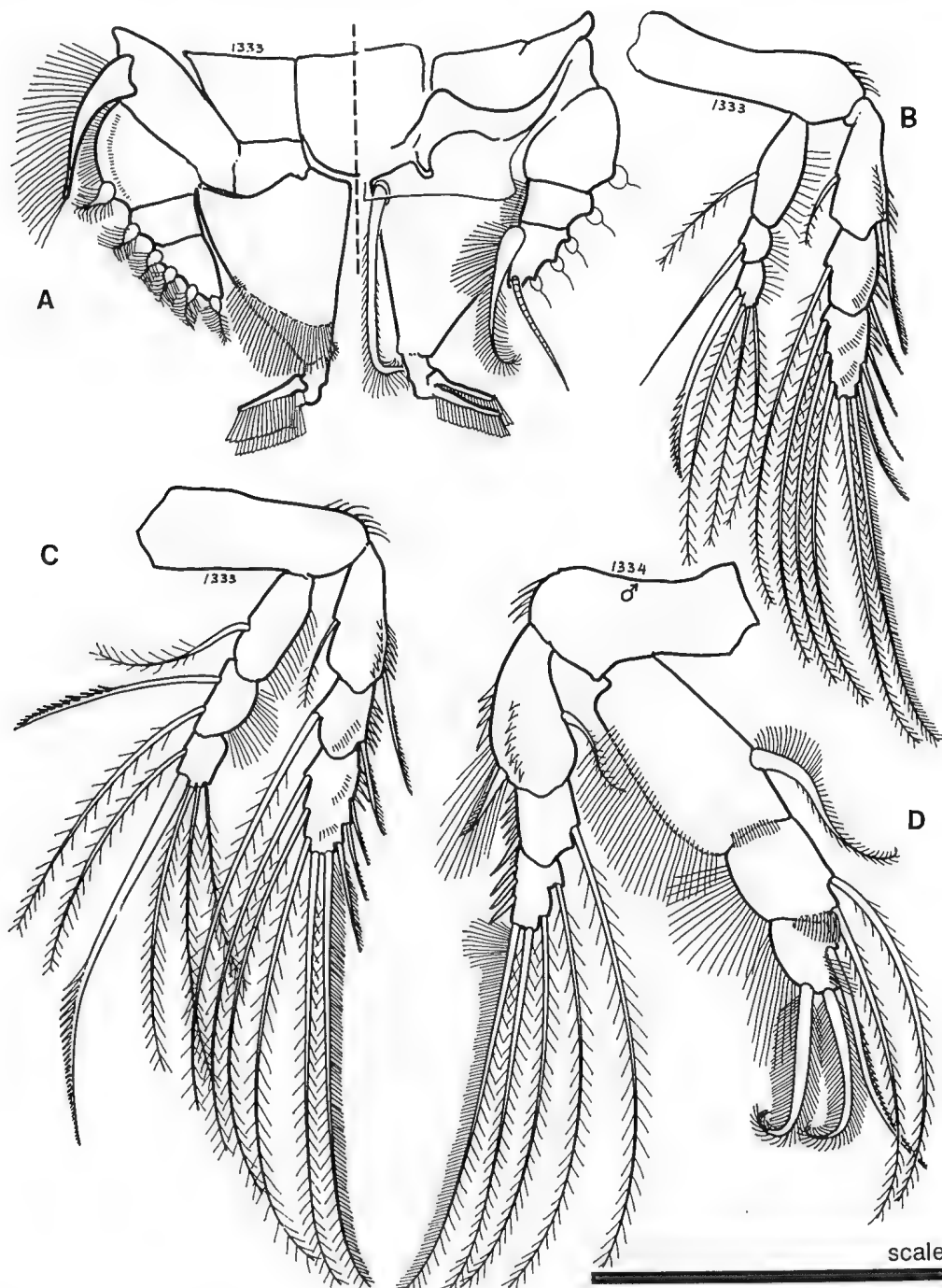
21 females (17 carrying eggs), 29 males (1 coupled to juvenile female)]. Washed from stones encrusted with pink 'Lithothamnion' in infralittoral fringe, sheltered bay on north side of O'Hara Head, Kioloa, NSW (35°30'S 150°22'E), 19 Jan. 1977, V.A.P. Harris.

**Diagnosis.** *Adult female.* Colourless with 2 large red patches, one on cephalosome the other on urosome; mean length 0.76 mm; rostrum width 0.12 mm, ratio of cephalosome width to rostrum 4.25; dorsal surface pitted;

urosoma broad, semicircular with lateral cleft; caudal rami rhomboidal,  $\alpha$  and  $\beta$  setae close together, terminal seta 4 large, pinnate, situated at apex, 2 and 3 fine, close together and parallel to posterior border; no peg field on endopod of P1.

*Adult male.* No red patch on urosome, corner of antennule socket obscured, shoulder with 'epaulet'; antennule with ventral blade.

**Dimensions.** *Females.* Mean length 0.76 mm (SD =



**Fig. 21.** *Kioloaria sesquimaculata*. A – P1 (left ventral, right dorsal); B – P4; C – P3; D – male P2. Scale bar: A = 0.19 mm; B,C = 0.165 mm; D = 0.12 mm.



0.015,  $N = 18$ ), cephalosome width 0.51 mm ( $SD = 0.012$ ), height 0.12 mm, body length to width ratio 1.49. Rostrum 0.12 mm, ratio of cephalosome width to rostrum 4.25. Urosome width to length ratio 1.52. Caudal ramus length to width ratio 2.48.]

**Males.** Mean length 0.59 mm ( $SD = 0.009$ ),  $N = 20$ ), cephalosome length 0.36 mm, width 0.44 mm ( $SD = 0.007$ ), ratio of body length to width 1.34.

**Adult female** (Fig. 19A). Cephalosome with dorsal hump in midline above rostrum (Fig. 19C). Rostrum

prominent with anterior hyaline border. Dorsal surface of body pitted. Hyaline border to cephalosome and metasome 10  $\mu\text{m}$  wide.

Urosome broad (Fig. 20B), anterior and posterior lobes separated by deep cleft, bordered with setules, medial corner of posterior lobe rounded. Caudal arch deep (almost half length of urosome).

Caudal rami rhomboidal with oblique posterior border slightly emarginate (Fig. 19G).  $\alpha$  and  $\beta$  setae proximal, close together; terminal seta 1 crescentic, unipinnate, terminal seta 4 large, pinnate, situated at

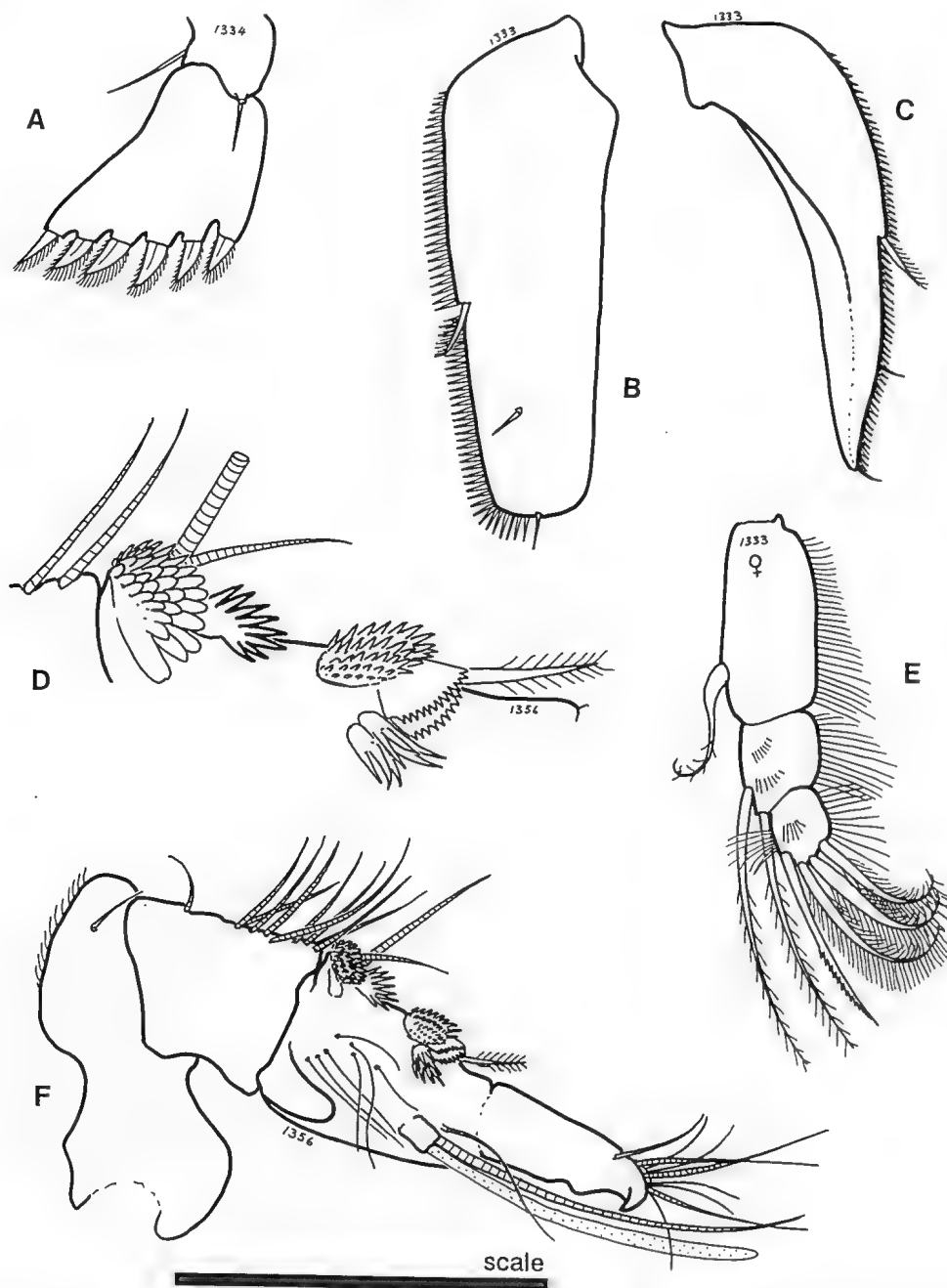


Fig. 22. *Kioloaria sesquimaculata*. A – male P5; B – female P5 laid flat; C – female P5 ventral view in natural position; D – coupling denticles of male antennule; E – female P2 endopod; F – male antennule with terminal segment extended (ventral view). Scale bar: A = 0.165 mm; B,C = 0.22 mm; D = 0.045 mm; E = 0.19 mm; F = 0.1 mm.

apex, 2 and 3 fine, close together, lying parallel and dorsal to posterior border (Fig. 19E); fine setules present along medial and lateral edges and are continuous with a terminal fringe of very fine setules.

Limbs (Figs 20-22) show typical setation. Antenna with pectinate spatulate claw on endopod, terminal portion of geniculate setae plain (Fig. 20E). Mandible as shown in Figure 20A. Maxillule with 2 setae on exopod, 6 setae on endopod, endites each bear 3 setae (Fig. 20C). Maxilla as shown in Figure 20G. Medial lobe of maxilliped rounded with fimbriate border, prominent coxal seta, basis with fimbriate border and fimbriate process (Fig. 20H). First pereopod (P1, Fig. 21A) with a row of fine denticulate ridges on article 1 of exopod, no field of denticulate pegs on endopod. P2 with serrulate spinous seta plus 3 plumose setae on article 3 of endopod (Fig. 22E). Serrate sabre-like seta on P3 endopod (Fig. 21C) considerably longer than endopod (1.6 : 1). External serrulate spinous setae on P3 and P4 exopod unusually long (Fig. 21B,C). Distal article of P5 falciform in natural position (Fig. 22C), oblong, truncated posteriorly with rounded corners when laid flat (Fig. 22B), bordered with setules, 1 dorsal and 1 apical seta; the P5s touch posteriorly and completely enclose the urosome and caudal rami (Fig. 19A).

**Adult male** (Fig. 19B). Anterior outline of cephalosome a truncated oval, bluntly pointed in midline, lateral angle of antennule socket visible from dorsal view, shoulders rounded with double 'epaulets' (Fig. 19D). Surface pits and hyaline border as for female.

Urosome (Fig. 20F) with seta between small anterior lobe and posterior lobe, 2 setules at apex of posterior lobe.

Caudal rami quadrate (Fig. 19F).  $\alpha$  and  $\beta$  seta close together, terminal setae 2 and 3 close together, not parallel to posterior border.

Antennule prehensile (Fig. 22F); accessory lobe with very large denticulate tubercle and small ventral blade (Fig. 22D); proximal coupling denticle serrate palmate, medial denticle oval covered in pointed denticulations, distal denticle with serrate edge, associated with plumose seta; distal segment of antennule long (equal in length to compound segment), with hook-like distal end. First pilose seta of mandibular palp slender (Fig. 20D). P1, P3 and P4 as for female. P2 with 3 setae (1 serrulate spinous, 2 plumose) on article 3 of endopod (Fig. 21D). P5 broad with 6 pinnate terminal setae (Fig. 22A).

**Remarks.** Living animals are sexually dimorphic in their colouration. Females have a large carmine red patch on the dorsal part of the cephalosome and a smaller crescentic patch on the urosome, caudal rami and falciform ridge of P5, the rest of the body is colourless. Males have only a red patch on the cephalosome and first metasome, the rest of the body is colourless. The specific name refers to the smaller red patch at the

rear of the female (*L. sesqui* = one half more + *macula* = a spot).

**Distribution and abundance.** Small populations (15+) of *Kioloaria sesquimaculata* have been found only at Kioloa, NSW where they occur on stones covered in pink *Lithothamnion* from the infralittoral fringe. Isolated specimens have been recorded from Cronulla, Sydney, NSW.

### *Brevifrons* n.gen.

**Diagnosis.** Anterior of female cephalosome truncated, rostrum obscured; hyaline border present, dorsal pits absent, honeycomb-like ridges present; urosome broad, with epimeral expansions to form anterior and posterior lobes, caudal ramus included in caudal arch of urosome; caudal rami rectangular, deeply emarginate,  $\alpha$  and  $\beta$  setae close together, all terminal setae similar, equally spaced; maxillule endopod with 2 setae; maxilliped basis with fimbriate process, coxal lobe fimbriate; male P2 endopod with 2 plumose terminal setae; male P5 with 6 terminal setae; female P5s do not touch one another posteriorly.

**Species composition.** *Brevifrons faviolatum* n.sp.

**Remarks.** This genus is characterised by a number of unusual features of which the presence of only two setae on the endopod of the maxillule, a honeycomb-like pattern of raised ridges on the dorsal surface and the absence of pits are the most significant. The anterior outline of the female cephalosome is truncated and the ventral rostrum obscured from view (features usually associated with male animals; this gives rise to the generic name (*L. brevis* = short + *frons* = forehead). Another unusual feature is their ability to roll up into a ball (conglobate).

One species is described with a wide distribution in New South Wales.

### *Brevifrons faviolatum* n.sp.

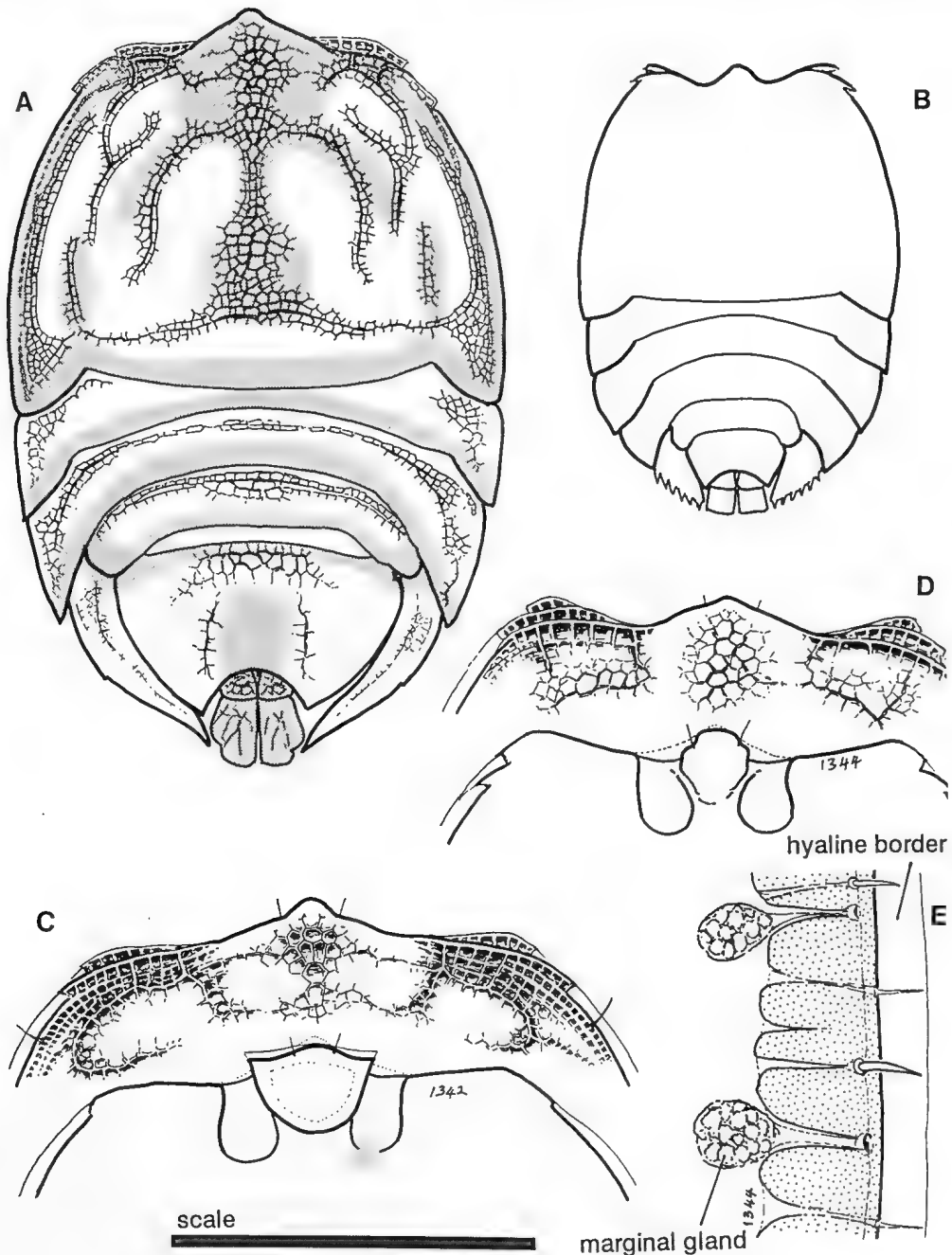
Figs 23-26

**Type material.** HOLOTYPE adult female with egg mass, AM P42315; ALLOTYPE adult male, AM P42316; PARATYPES 2 females, 3 males (2 coupled to female copepododes), AM P42317; 3 females, 3 males [Cr.32] designated paratypes BM(NH) 1992.567-572. Dissected paratype specimens (slides 1152, 1154, 1342 female, 1344 male) from which illustrations were made, together with remaining type population held at ZANU, registration Po.D. [Ki.54] [total type population 17 females, 11 males plus 8 males coupled with juvenile females]. Washed from loose stones in the infralittoral fringe, north side of O'Hara Head, Kioloa, NSW (35°30'S 150°22'E), 27 Apr. 1979, V.A.P. Harris.

**Diagnosis.** *Adult female.* Yellow with brown border to cephalosome; mean length 1.0 mm; cephalosome truncated anteriorly, extended in midline as triangular bulge which completely obscures rostrum; rostrum width 0.11 mm, ratio of cephalosome width to rostrum 6.0; dorsal surface with honeycomb pattern, pits absent; urosome broad, without notch or scar; caudal rami rectangular, widening posteriorly, strongly emarginate,  $\alpha$  and  $\beta$  seta close together, terminal setae all pinnate, equally spaced; small peg field on P1 endopod.

*Adult male.* Colouration as for female; cephalosome concave anteriorly with triangular projection in midline, shoulder with double 'epaulet'; no ventral blade on antennule.

**Dimensions.** *Females.* Mean length 1.0 mm (SD = 0.011, N = 11), cephalosome width 0.7 mm (SD = 0.008), height 0.3 mm, body length to width ratio 1.43. Rostrum 0.11 mm, ratio of cephalosome width to rostrum 6.0. Urosome width to length ratio 1.48. Caudal length



**Fig. 23.** *Brevifrons faviolatum*. A – adult female, shaded areas represent brown colouration; B – adult male (note reduced scale); C – female rostrum and anterior border of cephalosome (dorsal and ventral views); D – male rostrum and anterior border of cephalosome (dorsal and ventral views); E – edge of cephalosome showing hyaline fringe, marginal glands and sensory setae. Scale bar: A = 0.55 mm; B = 0.72 mm; C, D = 0.35 mm; E = 0.1 mm.

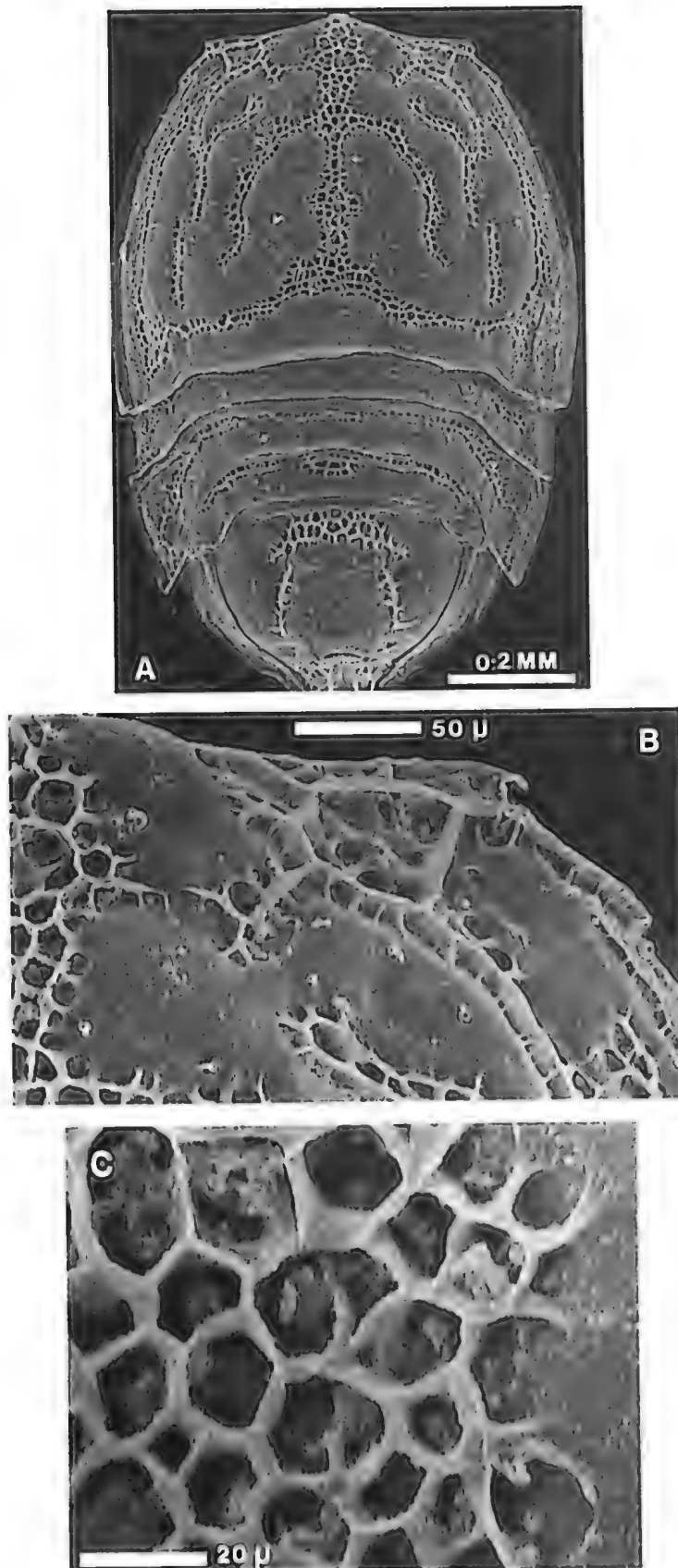


Plate 1. *Brevifrons faviolatum* (female). A – dorsal pattern of reticulate ridges. SEM micrograph. Scale bar = 0.2 mm. B – right shoulder showing absence of pits. SEM micrograph. Scale bar = 50 μm. C – reticulate ridges from dorsal midline. SEM micrograph. Scale bar = 20 μm.

to width ratio 1.62.

**Males.** Mean length 0.83 mm (SD = 0.011, N = 7), cephalosome length 0.52 mm, width 0.62 mm (SD = 0.007), ratio of body length to width 1.3.

**Adult female** (Fig. 23A). Cephalosome truncated anteriorly, extended forwards in midline as a triangular bulge which completely obscures the rostrum from dorsal view. Shoulders rounded with double 'epaulet' (Fig. 23C). Rostrum ventral, with hyaline border. Dorsal

surface of cephalosome, metasome, urosome and caudal rami ornamented with ridges and areas of honeycomb pattern (Fig. 23A,C and Pl. 1); dorsal sensory setae present but circular pits absent. Hyaline border 15  $\mu$ m wide, marginal glands open dorsal to hyaline border (Fig. 23E).

Urosome broad (Fig. 24A), no trace of division into anterior and posterior lobes, no lateral notch or scar, no border setules except at posterior apex. Caudal arch shallow (about one-third length of urosome).

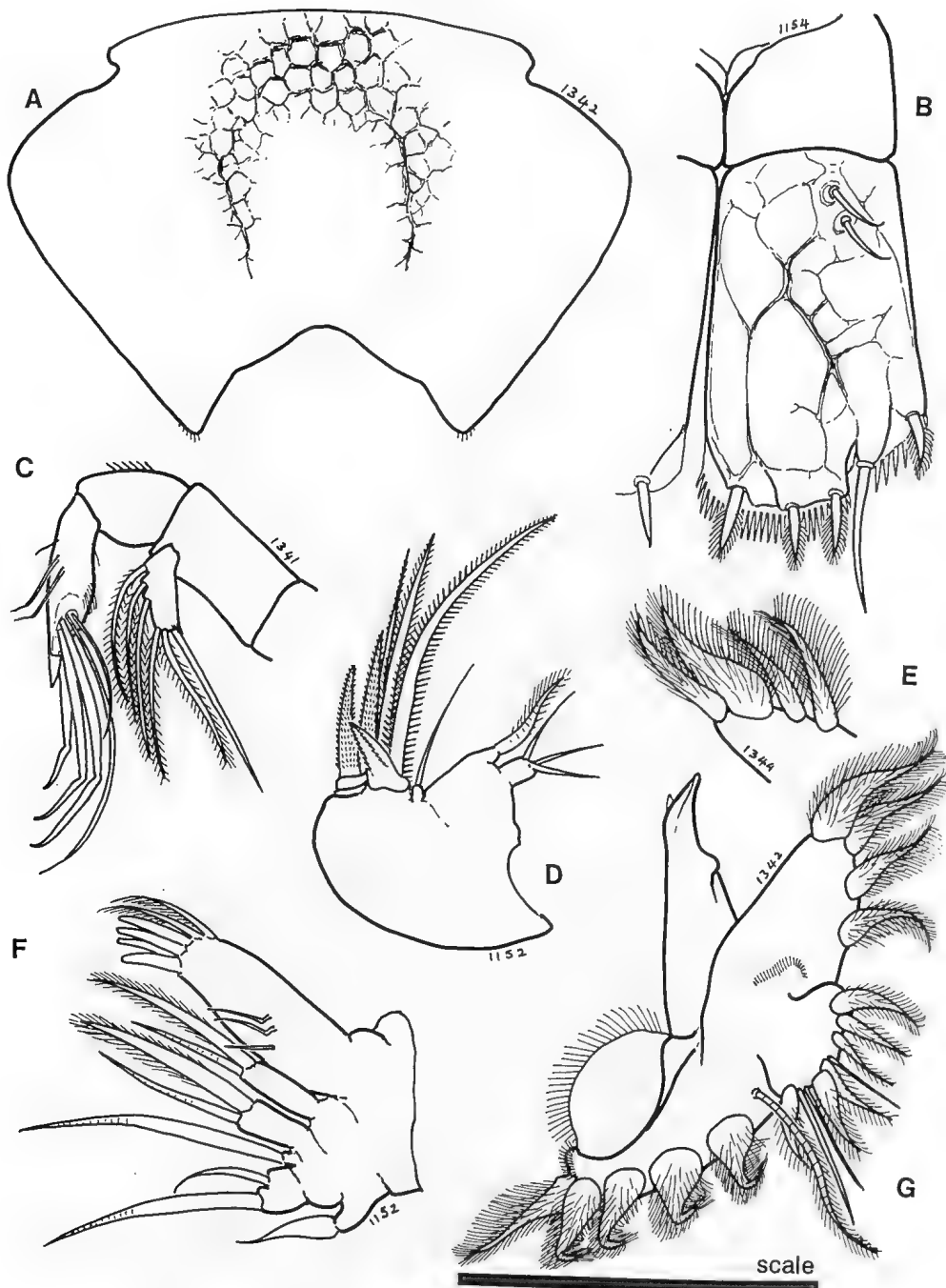


Fig. 24. *Brevifrons faviolatum*. A – female urosome; B – female right caudal ramus; C – antenna; D – maxilla; E – male anterior palp of mandible; F – maxillule; G – female mandible. Scale bar: A = 0.26 mm; B,D = 0.12 mm; C = 0.165 mm; E not to scale; F = 0.075 mm; G = 0.19 mm.

Caudal rami rectangular (Fig. 24B), widening slightly posteriorly (maximum width three-quarters way down ramus), strongly emarginate.  $\alpha$  and  $\beta$  setae proximal, close together,  $\gamma$  seta in emargination; terminal setae all pinnate, equal in size and equally spaced (2 and 3 not close together); wide terminal fringe of setules. More than half length of caudal ramus projects beyond urosome (Fig. 23A).

Limbs with typical setation (Figs 24-26). Spatulate

claw on endopod of antenna (Fig. 24C) very small, not pectinate, geniculate setae plain, exopod with 1 plain and 5 plumulose setae. Anterior lobe of mandibular palp large with row of ventral setules, incisor process narrow, chisel-like (Fig. 24G). Maxillule (Fig. 24F) with single seta on exopod, 2 setae on endopod, 1 seta on distal endite, 2 setae (1 plumose) on each of the proximal endites, gnathobase very long (about 3 times width). Maxilla (Fig. 24D) with single plumose seta on medial

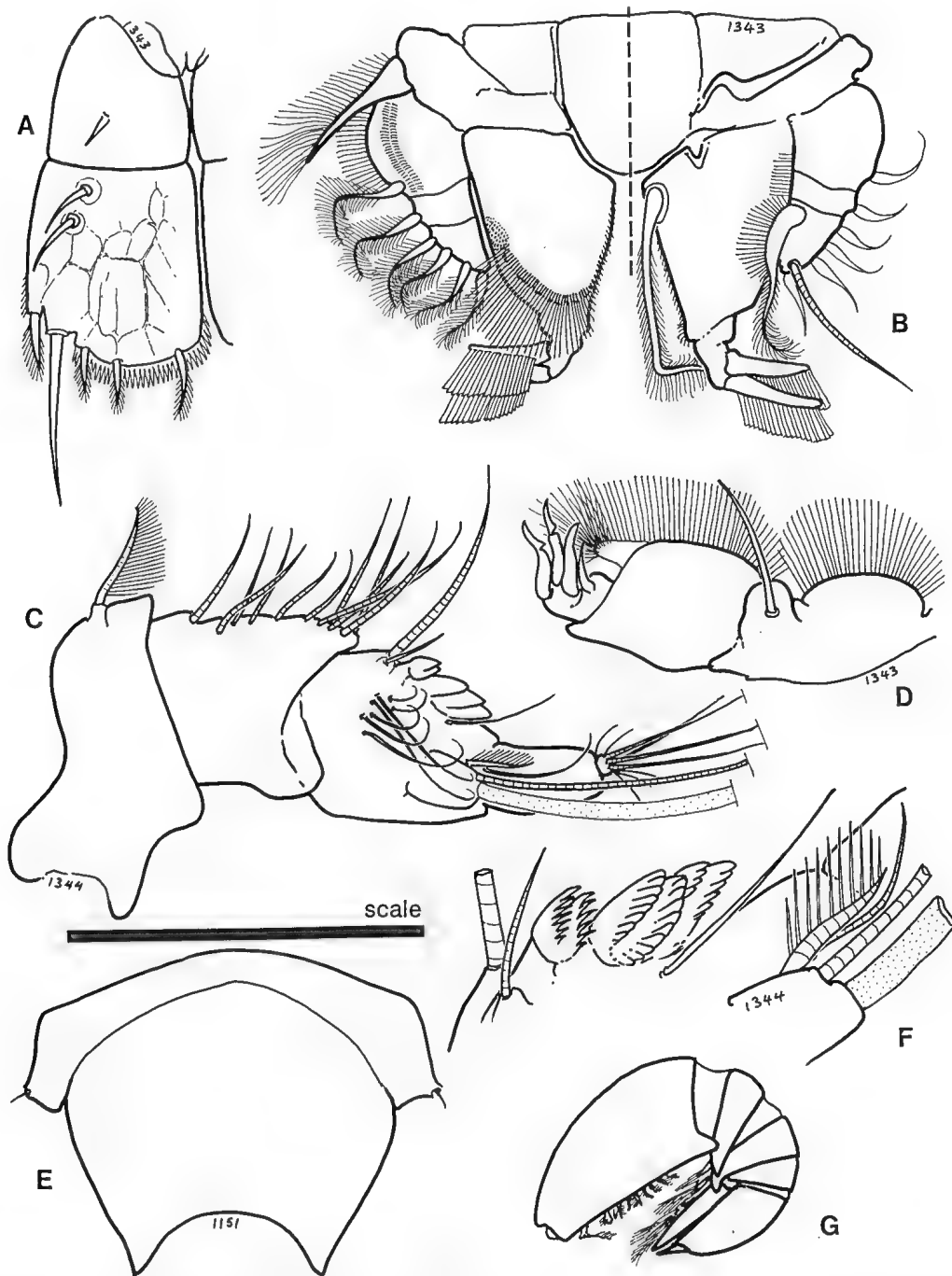


Fig. 25. *Brevifrons faviolatum*. A – male left caudal ramus; B – P1 (left ventral, right dorsal); C – male antennule with terminal segment extended (ventral view); D – maxilliped; E – male urosome; F – coupling denticles of male antennule; G – adult female in conglobating posture viewed from left side. Scale bar: A,D = 0.12 mm; B,E = 0.22 mm; C = 0.1 mm; F = 0.045 mm; G not to scale.

endite, spatulate claw with 2 serrate edges. Medial lobe of maxilliped rounded with fimbriate edge (Fig. 25D), basis with fimbriate border and short fimbriate process. First pereopod (P1, Fig. 25B) with double row of denticulate pegs on article 1 of exopod, small lateral field of denticulate pegs beyond fimbriate crescent on endopod. P2 endopod slender with row of spinous setules on proximal article, 1 serrulate spinous seta and 3 plumose setae on distal article (Fig. 26E). Serrate sabre-like seta on P3 endopod short (1.2:1), (Fig. 26A).

P4 with 3 serrulate spinous setae on endopod (Fig. 26C). P5 bluntly lanceolate with terminal seta, fringe of spinous setules (Fig. 26F), P5s reach beyond urosome as far as emarginate indentation on caudal rami, but do not touch posteriorly (see Fig. 23A).

**Adult male** (Fig. 23B). Anterior of cephalosome concave with triangular bulge in midline, shoulders angular with double 'epaulet' (Fig. 23D). Colouration, reticulate ornamentation and hyaline border as for female.

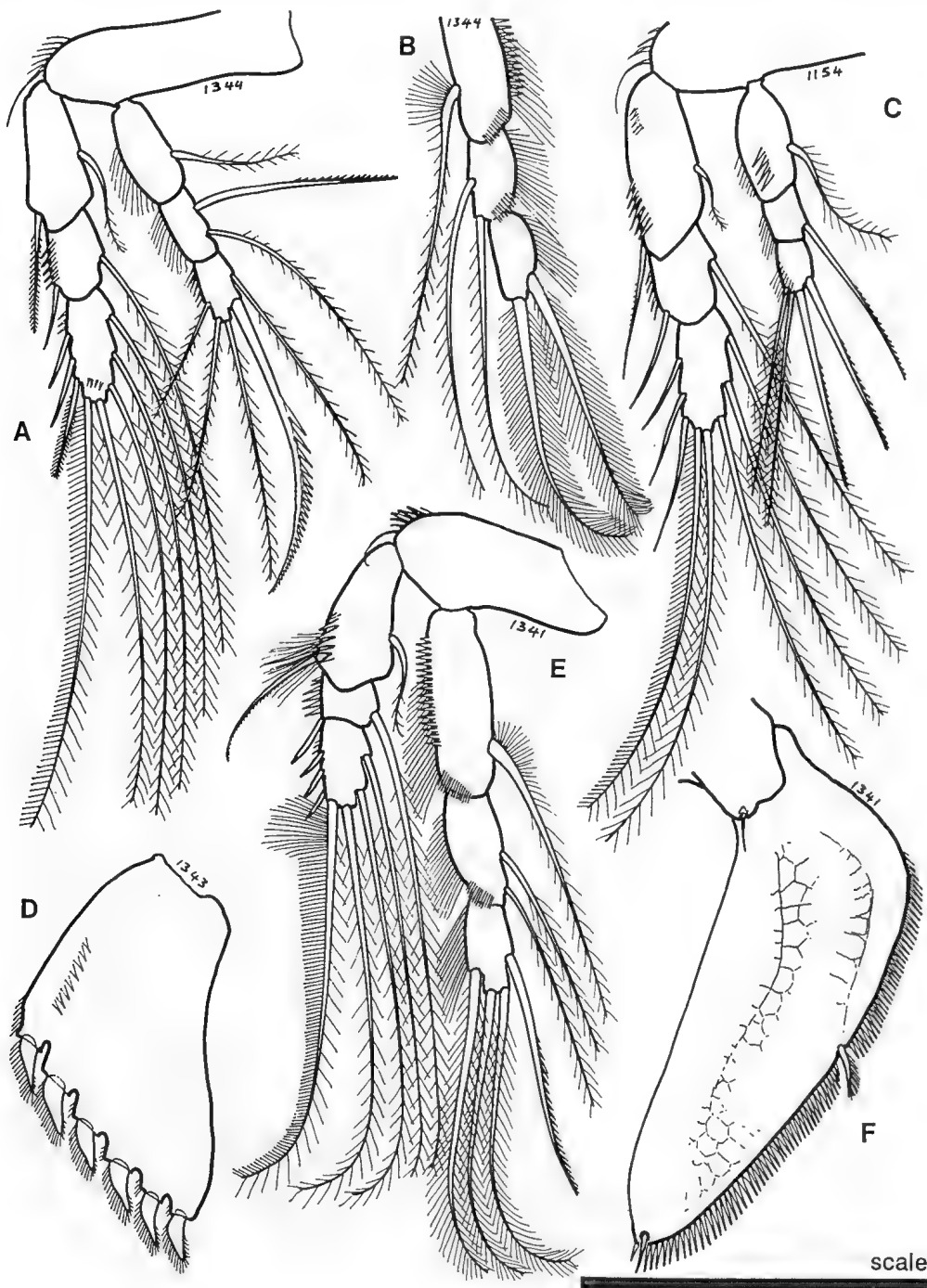


Fig. 26. *Brevifrons faviolatum*. A - P3; B - male P2 endopod; C - P4; D - male P5; E - female P2; F - female P5 (dorsal view). Scale bar: A,B,C,E = 0.19 mm; D = 0.165 mm; F = 0.22 mm.



Urosome as in Figure 25E, no apical setules. Caudal rami rectangular with emargination, setation similar to female (Fig. 25A).

Antennule prehensile (Fig. 25C); seta on article 1 plumose; ventral blade absent; coupling denticles with serrate edges (Fig. 25F), seta associated with distal denticle plain; articulate plumose seta situated near base of ventral sensory lobe bearing aesthetasc (Fig. 25F); terminal segment about half length of compound segment. First pilose seta on mandibular palp not greatly swollen (Fig. 24E). P1, P3, P4 as for female, P2 endopod with 2 plumose setae on terminal article (Fig. 26B). P5 as shown in Figure 26D.

**Remarks.** Adults are yellow with a reddish-brown border to the cephalosome and along joints between metasomal segments. A more diffuse pattern occupies midline of the cephalosome and urosome (Fig. 23A). The anal segment and caudal rami are also reddish-brown. The specific name is descriptive of the honeycomb reticular pattern on dorsal parts of the body (*L. favus* = honeycomb).

Modest populations (25+) have been collected only from Kioloa and Cronulla, Sydney. All specimens from

Kioloa have been collected from small stones (some sparsely encrusted with coralline algae or stunted *Lobophora*) under large boulders in rockpools below Chart Datum, and associated with the ophiuroid/*Phascolosoma* (Sipunculida) community. At Cronulla specimens were collected from stones encrusted with stunted *Sargassum* or *Lobophora* in rock gullies about Chart Datum.

**Distribution and abundance.** Occasional isolated individuals of *Brevifrons faviolatum* have been washed from *Lobophora* at Broulee in the south and as far north as Nambucca and Arrawarra Headlands, NSW.

### *Porcellidium* Claus 1860

The genus *Porcellidium* has been divided into three sub-groups (Harris & Robertson, 1994) on the presence or absence of a ventral blade to the male antennule and the position of setae 2 and 3 on the caudal ramus.

Species possessing a ventral blade were subdivided as follows:

Terminal setae 2 and 3 very close together, plain, fine ..... Hormosirii subgroup

Terminal setae 2 and 3 not very close, resemble 1 and 4, thick, pinnate .....  
..... Fimbriatum subgroup

#### 'Fimbriatum' subgroup

##### *Porcellidium londonii* n.sp.

Figs 27-30

**Type material.** HOLOTYPE adult female with egg mass, AM P42318; ALLOTYPE adult male, AM P42319; PARATYPES 2 females, 2 males (1 coupled to female copepod), AM P42320; 4 females, 2 males [Cr.27, Mb.4] designated paratypes BM(NH) 1992.516-522. A second population [Ki.1] with 9 females and 8 males, taken from the same locality (21 Nov. 1972, V.A.P. Harris), has been designated paratype material. Illustrations were made from dissections of paratypes (slides 1328, 1329 female, 1330, 1331 male). These and the remaining type population held at ZANU, registration Po.SA. [Ki.35, Ki.1] [total type population 13 females (9 carrying eggs), 14 males plus 6 males coupled with juvenile females]. Washed from stones encrusted with pink 'Lithothamnion' in the infralittoral fringe, sheltered bay on north side of O'Hara Head, Kioloa, NSW (35°30'S 150°22'E), 19 Jan. 1977, V.A.P. Harris.

**Diagnosis.** *Adult female.* Pink with 4 pale blue iridescent spots on the cephalosome and iridescent blue scar on the urosome; mean length 0.75 mm; rostrum width 0.1 mm, hardly visible from above, ratio of cephalosome width to rostrum 5.0; dorsal surface pitted; urosome broad semicircular with prominent scar, no

lateral notch; caudal rami rectangular,  $\beta$  seta near  $\gamma$ , terminal setae all pinnate; small lateral triangular peg field on P1 endopod.

*Adult male.* Colouration as for female; corners of antennule sockets just visible from above, shoulders tightly rounded; ventral blade present on antennule.

**Dimensions.** *Females.* Mean length 0.75 mm (SD = 0.015, N = 13), cephalosome width 0.51 mm (SD = 0.019), height 0.11 mm, body length to width ratio 1.47. Rostrum width 0.1 mm, ratio of cephalosome width to rostrum 5.0. Urosome width to length ratio 1.4. Caudal ramus length to width ratio 2.2.

*Males.* Mean length 0.57 mm (SD = 0.008, N = 13), cephalosome length 0.33 mm, width 0.43 mm (SD = 0.011), ratio of body length to width 1.32.

**Adult female** (Fig. 27A). Cephalosome extended forward in the midline as a bulge which almost obscures the rostrum (Fig. 27C). Rostrum with narrow hyaline anterior edge. Hyaline border to cephalosome and epimeral lobes 8  $\mu$ m wide. Dorsal surface of body pitted. On the caudal rami there is a reticulate pattern of ridges (Fig. 28A).

Urosome broad, semicircular in outline (Fig. 28B), very small notch between anterior and posterior lobes, prominent scar, both lobes bordered with fine setules.

Caudal arch of urosome deep (about half urosome length).

Caudal rami (Fig. 28A) long, rectangular, slightly wider distally, not emarginate.  $\alpha$  seta close to anal segment,  $\beta$  seta close to  $\gamma$  seta; all terminal setae thick, pinnate, 2 and 3 close together, 4 set in slightly from medial corner; terminal fringe of very fine setules present. Caudal rami project slightly beyond caudal arch.

Limbs with typical setation (Figs 28-30). Spatulate claw on endopod of antenna pectinate, terminal portion of geniculate setae plain (Fig. 29A). Mandible with strong incisor process (Fig. 28G). Maxillule exopod with 2 setae (1 very fine), endopod with 6 setae, endites each bear 3 setae (Fig. 28F). Maxilla as shown in Figure 28D,E. Medial lobe of maxilliped rounded with fimbriate border, basis with fimbriate border and fimbriate process (Fig. 29E). First pereopod (P1, Fig. 29B) with crescentic row of denticles on article 1 of exopod, small triangular peg field at lateral end of fimbriate crescent on endopod. P2 endopod with 1 serrulate seta and 3 plumose setae on terminal article (Fig. 30E). Serrate sabre-like seta of P3 endopod considerably longer than

endopod (1.5 : 1) (Fig. 30F). Distal article of P5 (Fig. 30B) ovate, bluntly pointed laid flat, falciform in natural position (Fig. 30A), 1 dorsal plus 1 terminal seta. P5 does not reach as far as posterior lobe of urosome (Fig. 27A).

**Adult male** (Fig. 27B). Cephalosome truncated anteriorly, convex in midline, lateral angle of antennule socket just visible from above, shoulders angular (Fig. 27D). Hyaline border and pits of cephalosome as for female.

Urosome anterior lobe bulges laterally, prominent seta between anterior and posterior lobes, single apical setule (Fig. 28H).

Caudal rami quadrate, wider posteriorly, lateral and medial corner bevelled (Fig. 29C).  $\beta$  seta midway between  $\alpha$  and  $\gamma$ , terminal setae pinnate, 4 set in from medial corner.

Antennule prehensile (Fig. 29F); accessory lobe with anterior spine and ventral blade; proximal and medial coupling denticles with toothed edges, distal denticle with double serrate edge (Fig. 29G); distal segment of antennule with concave anterior (medial) border and

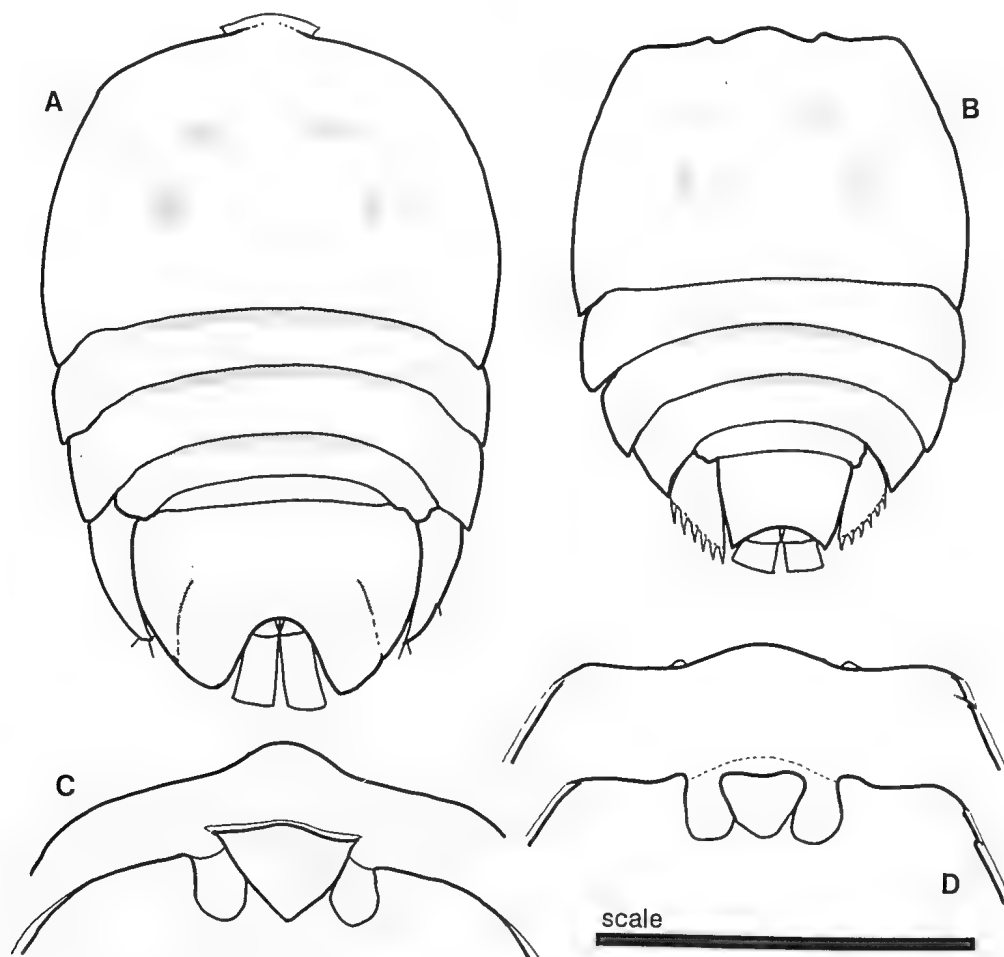


Fig. 27. *Porcellidium londonii*. A – adult female, shaded areas iridescent pale blue, body colour magenta pink; B – adult male; C – female rostrum and anterior border of cephalosome (dorsal and ventral views); D – male rostrum and anterior border of cephalosome (dorsal and ventral views). Scale bar: A,B = 0.45 mm; C,D = 0.33 mm.

hook-like terminal portion (Fig. 29F). First pilose seta of mandibular palp slender (Fig. 28C). P1, P3 and P4 as for female. P2 with 2 plumose setae on distal article of endopod (Fig. 30D). P5 broad with 6 terminal setae (Fig. 29D).

**Remarks.** Adult animals are carmine pink with four pale blue iridescent patches near the trabeculae, along joints between segments and on the urosome scar. This iridescence is distinctive and appears to be a structural

colour for its intensity depends on the angle of illumination, however, SEM studies have not revealed any surface structures which might give rise to the colour. It is interesting to note that the colour of this species accurately matches the colour of rocks on which it lives.

*Porcellidium londonii* has been named after Edith and Joy London, benefactors to the Australian National University. Their property, donated to the University, has become the London Foundation Field

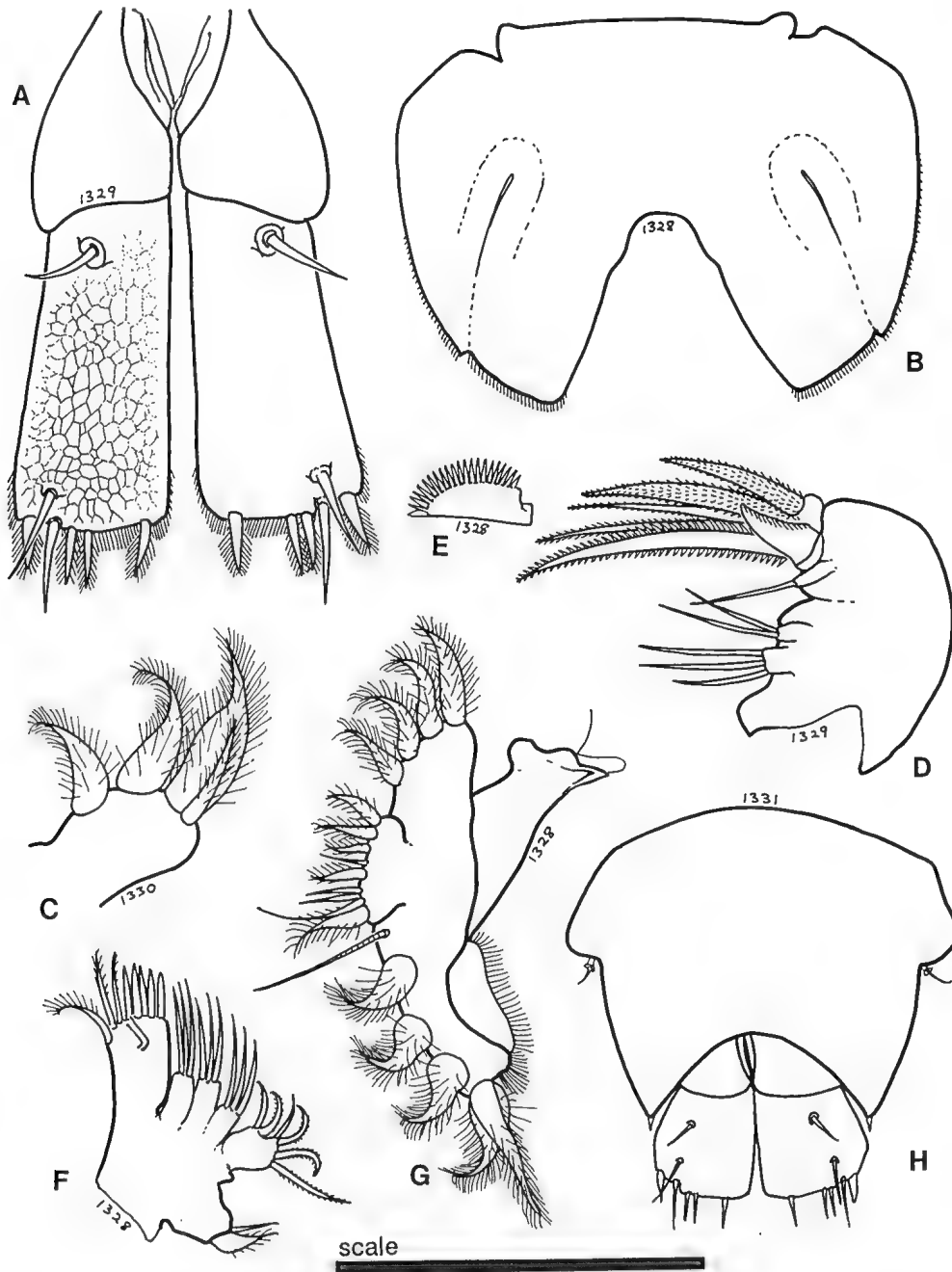


Fig. 28. *Porcellidium londonii*. A – female caudal rami and anal segment; B – female urosome; C – male anterior mandibular palp; D – maxilla; E – spatulate seta of maxilla; F – maxillule; G – female mandible; H – male urosome and caudal rami. Scale bar: A = 0.12 mm; B = 0.26 mm; C and E not to scale; D, F = 0.1 mm; G, H = 0.165 mm.

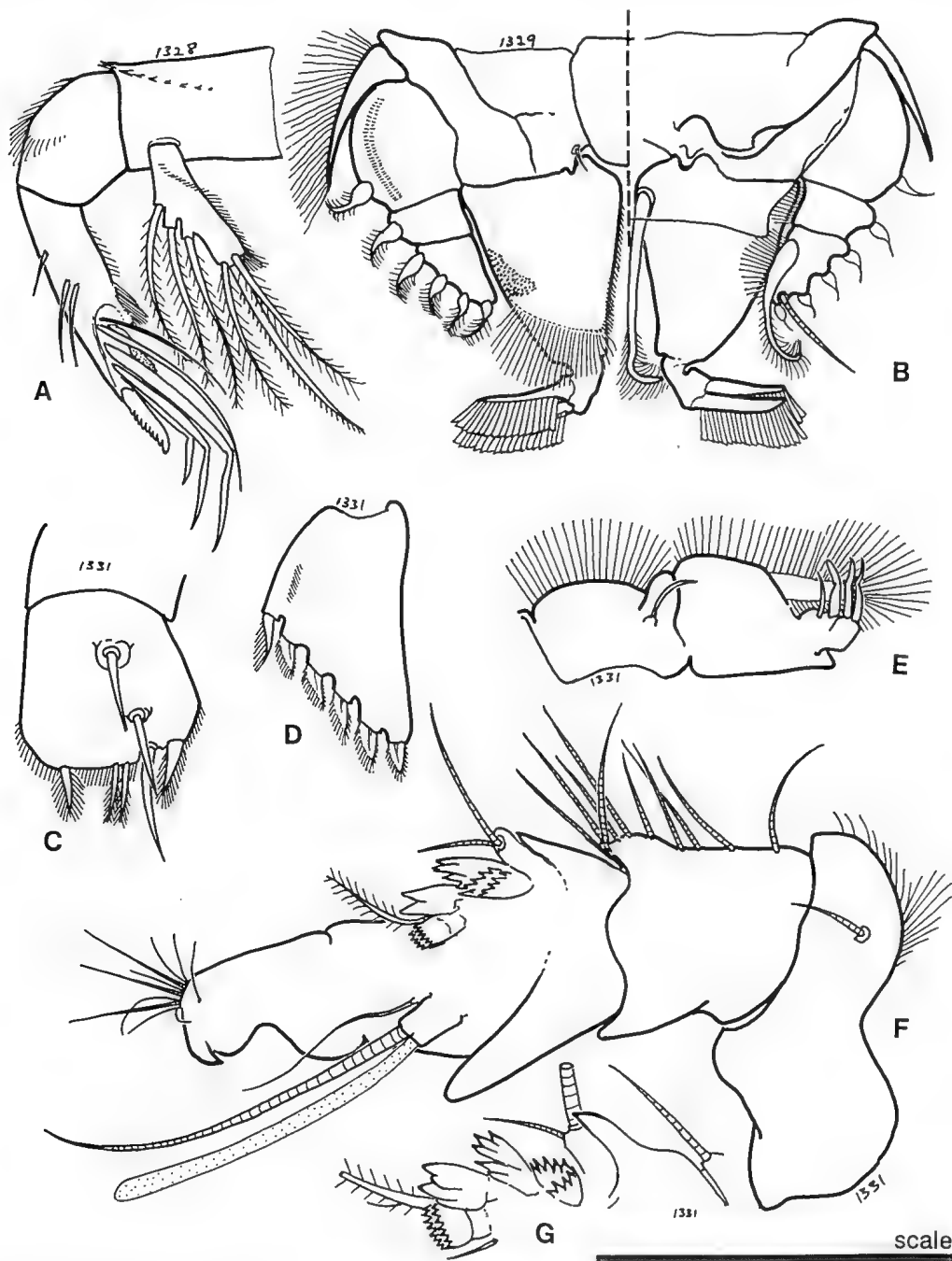
Station, Kioloa, NSW.

## Discussion

**Distribution and abundance.** The type population was washed from stones and boulders covered with a thin encrustation of 'Lithothamnion' and regularly browsed by the sea urchin *Centrostephanus rogersii* in the infralittoral fringe. It has only been found in small numbers or isolated individuals. It has been recorded from Merimbula and Broulee in the south, and as far north as Cronulla, Sydney, NSW.

Several features in the foregoing descriptions have not received adequate explanation.

A hyaline fringe or border to the cephalosome and epimeral lobes of the metasome, a feature common to most of the Porcellidiidae, is not unique to that family for it is found in other species with a depressed body form, for example, *Zaus spinatus* (Harpacticidae) and *Aspidiscus littoralis* (Tisbidae).



**Fig. 29.** *Porcellidium londonii*. A – antenna; B – P1 (left ventral, right dorsal); C – male right caudal ramus; D – male P5; E – maxilliped; F – male antennule with terminal segment extended (ventral view,  $\pi$  setae omitted); G – coupling denticles of male antennule. Scale bar: A, C, E = 0.1 mm; B = 0.19 mm; D = 0.165 mm; F = 0.09 mm; G = 0.075 mm.

This hyaline border is colourless and does not stain with the chitin stain chlorazol black, indicating that it is non-chitinous. In some instances fine sensory setae appear to lie in the plane of the hyaline border.

The functional significance of the hyaline border has not been satisfactorily explained, but it is probable that it forms a seal round the edge of the body. The shape of the body is such that water of moderate or high velocity flowing over it will reduce pressure

above the animal relative to the periphery. With an efficient seal round the perimeter this would allow the animal to adhere passively by suction to the substratum (seaweed surface) without expenditure of energy. The tenacity with which specimens adhere to the surface in a jet of water from a pipette was noted by Bocquet (1948) who attributed this ability to a 'dispositif en ventrouse' or sucker formed by the mouthparts and anterior thoracic limbs. The success with which the Porcellidiidae have colonised the surface of seaweed

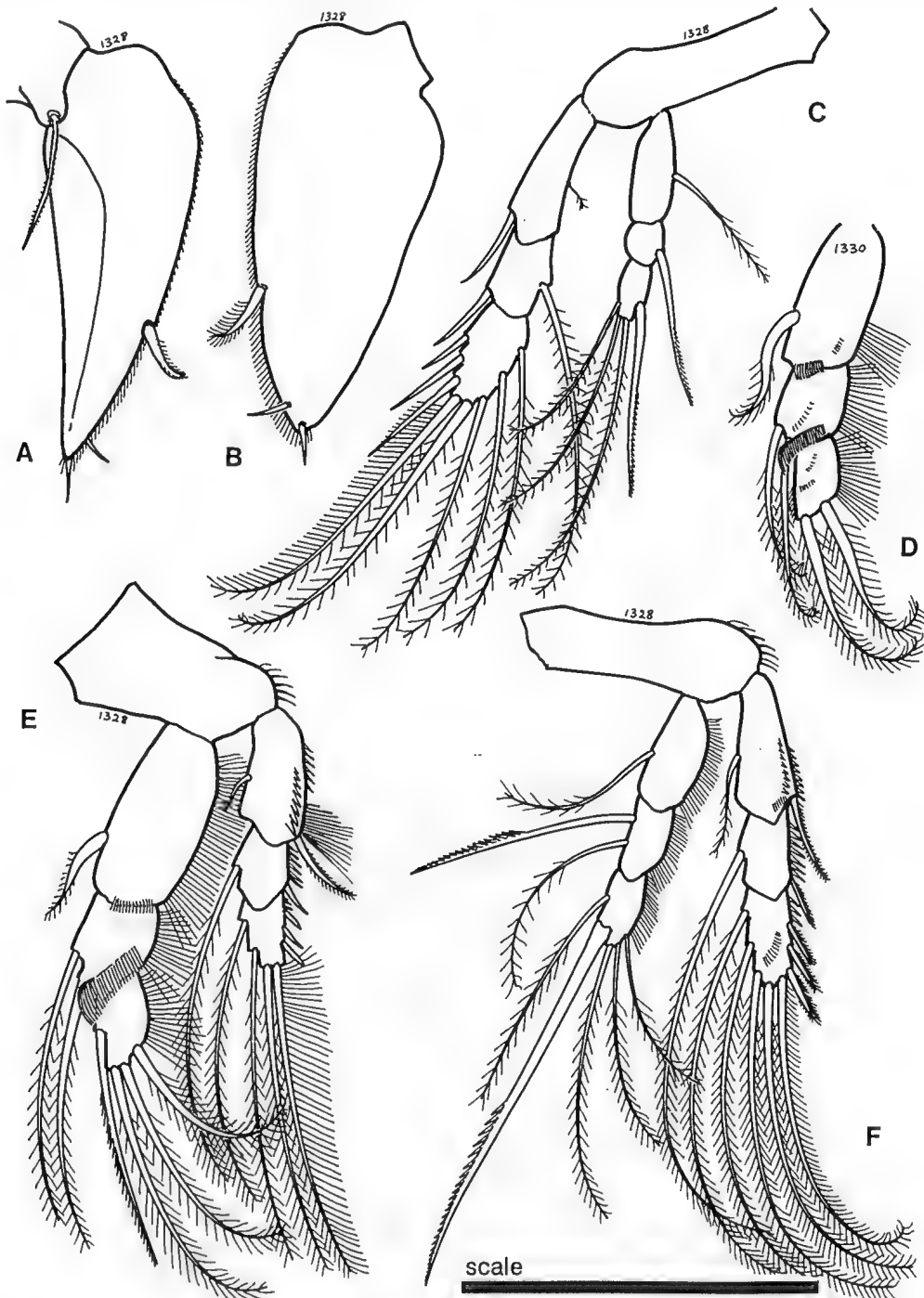


Fig. 30. *Porcellidium londonii*. A – female P5 in natural position (ventral view); B – female P5 laid flat (dorsal view); C – P4; D – male P2 endopod; E – female P2; F – P3. Scale bar: A-F = 0.165 mm.

under conditions of fast or turbulent water flow may well be due to possession of this hyaline border.

Towards the edge of the cephalosome and wedged between the lobes of the gonads, there are a variable number of marginal glands (between 5 and 12) that appear to be of holocrine type with a short duct that opens near to, but just above, the hyaline border (Figs 2C, 23E).

In the genus *Tectacingulum* the lateral border of the cephalosome has migrated ventrally to form a new ventral border (Fig. 2B). This results in the disappearance of the true hyaline fringe. Sensory setae are not normally found on the ventral (sternal) surface of the cephalosome, but with the edge being reflexed in *Tectacingulum*, both sensory setae and the opening of the marginal glands come to lie on the underside of the body (Fig. 2B,D). The ornamentation of ridges between pits on the dorsal surface gives the false impression of a hyaline border where it passes over the edge of the cephalosome, but this false border is chitinous, not hyaline, and has radial striations which are clearly related to the surface ridges (Fig. 2A,D, compare with 2C).

The dorsal surface of the cephalosome, metasomal segments, urosome, caudal rami and in some cases the fifth limbs (P5) show a wide range of surface ornamentation. The commonest takes the form of round, oval or crescent shaped pits which may have a raised rim or anterior border (see Harris & Robertson, 1994, pl. 1A). Ginneken & Bouligand (1975) have likened these to a lunar landscape with craters. Their electron micrographs of *Porcellidium viride* show surface microvilli and bacteria in the pits. Bacteria are commonly found in the pits on SEM photographs, but the significance of this and the function of the microvilli remains unanswered.

The cuticle between pits may be raised as a reticulate pattern of ridges; this is particularly noticeable on the caudal rami of some species (Figs 3C, 9F, 19G), or the anterior-lateral edge of the cephalosome (Figs 1D, 6D) where the rows of pits run tangential to the border. In *Brevifrons faviolatum* dorsal pits are absent. Their place is taken by prominent surface ridges which form a honeycomb pattern or rows of cubical recesses more or less parallel to the edge of the cephalosome (Figs 23A,C,D, 24A,B, Pl. 1).

Sensory setae, typically surrounded by a collar at their base, are a characteristic feature of the dorsal integument. They are always arranged in a symmetrical pattern characteristic of the species, but are much more numerous and obvious in some species than others.

Two pairs of limbs show important differences in structure which are of taxonomic value, but have received little comment in the past.

In the majority of species the endopod on the maxillule bears six plumulose setae and three or four setae on each of the three endites, but in *Brevifrons* there are only two setae on the endopod, two on each of the first two endites and only one on the third endite (Fig. 24F). This feature has been used as one of

the characters defining the genus *Brevifrons*.

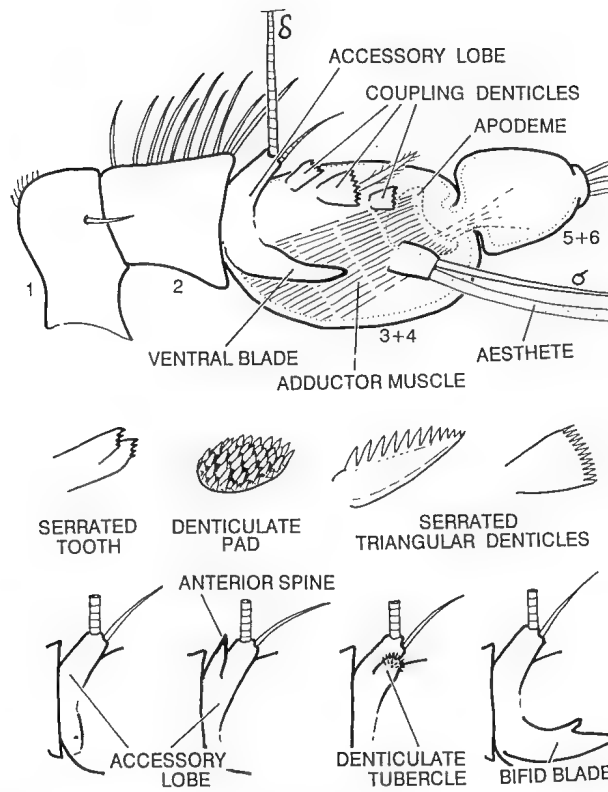
Males of most species show a reduction in the number of setae on the last article of the second pereopod (P2) when compared with females. In females the endopod of P2 invariably terminates in four setae (3 plumose plus 1 serrulate spinose seta). In male animals, this condition has only been recorded for *Porcellidium tristanense* (Hicks, 1982). In males of *Murramia magna*, *M. bicincta*, *Kioloaria sesquimaculata*, *Porcellidium echinophilum* (Humes & Gelerman, 1962), and presumably all the 'clavigerum complex' (Hicks, 1982), one of the plumose setae has been lost leaving one spinose and two plumose setae. In the males of *Porcellidium* (*sensu* Harris & Robertson), *Acutiramus*, *Tectacingulum*, and *Brevifrons*, the terminal setae of P2 are further reduced by the loss of the spinose seta leaving only two plumose setae. This feature has been used to separate genera.

Hicks (1982) has pointed out the potentially useful nature of the male antennule in porcellidid taxonomy, but no detailed study of this organ appears to have been undertaken.

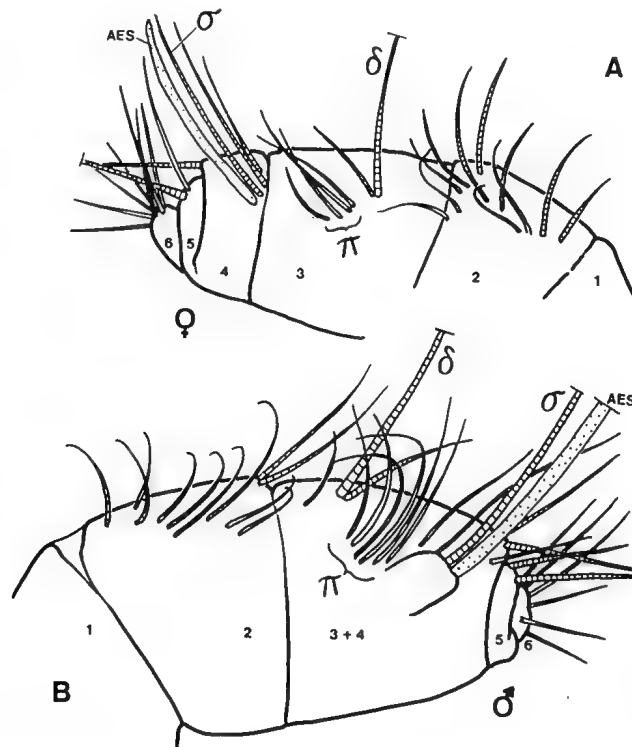
The male antennule is a difficult structure to study because the terminal segment is usually adducted in the 'clasping' position and this obscures the chitinous protuberances or coupling denticles which form such a valuable taxonomic character. The following account is based on SEM studies of Australian material using specimens in which the male antennules were extended in the 'hunting' position (ie, with terminal segment fully extended as shown in Figs 14B, 18E, 22F, 25C, 29F and 31A). This is a rare occurrence, being found in less than 1% of preserved specimens.

The antennule of male Porcellidiidae comprises four segments. The third (referred to as the compound segment) is greatly enlarged to accommodate the massive adductor muscle used to adduct the finger-like fourth segment (Fig. 31). At the base of the compound segment (ie, between it and segment 2) on the ventral side, many species have what will be referred to as an accessory lobe. Typically this bears two annulated setae on a short anterior prominence. One of these setae ( $\delta$ ) is usually much longer and held out at right angles to the antennule (ie, straight ahead); in *Porcellidium ulvum* Hicks, the  $\delta$  seta is whip-like and longer than the entire antennule (Hicks, 1982). The prominence on which these setae are carried may have an anterior spine or tubercle covered in small denticles (Fig. 31 bottom row). Ventrally and closer to the posterior border, the accessory lobe may be extended as a sclerotised process – the ventral blade. The ventral blade is easily seen if present and can be a useful taxonomic character. A second lobe (the sensory lobe) is located on the ventral surface distal to the ventral blade. It bears a long annulated seta ( $\sigma$ ) and the aesthete. Some species have two or three annulated setae inserted near the base of the sensory lobe. In *Brevifrons faviolatum* one of these setae is short and unipinnate (Fig. 25F).

Along the anterior edge of the compound segment there are typically one or more (usually 3) chitinous



**Fig. 31.** Diagram showing structure of male antennule in the family Porcellidiidae. Forms of coupling denticles (middle row) and accessory lobe (bottom row) shown in lower half of figure.



**Fig. 32.** *Porcellidium hormosirii*. A – antennule of fifth stage juvenile female showing segmentation and  $\delta$ ,  $\pi$  and  $\sigma$  setae; B – antennule of fifth stage juvenile male showing fusion of segments 3 and 4, setae  $\delta$ ,  $\pi$  and  $\sigma$  and absence of coupling denticles or ventral blade. Aes – aesthetasc.



protuberances, hereafter called the coupling denticles. They exhibit a wide variety of shape and are highly characteristic of each species. They range from a tooth-like structure to oval pads covered in peg-like denticulations. A common form is a triangular structure terminating in a serrated edge. In many cases the triangle is folded so that there appears to be a double row of distal serrations. In other cases the triangular structure is elongated with a serrated or pectinate (comb-like) lateral edge (Fig. 31 middle row). A short plumose seta is often found associated with one of the coupling denticles. On the ventral (palmar) side of the compound segment between the ventral blade (if present) and the coupling denticles there are typically seven, sometimes more, short plain setae (the  $\pi$  series, Figs 4E, 32B).

The terminal segment of the antennule varies in shape among species. It may range from long (up to two-thirds length of compound segment) to short (less than one-quarter length of compound segment), and bears a group of ten or 12 terminal setae. In certain species there may be a hook-like sclerotisation of the anterior distal edge or a c-shaped embayment.

The functional significance of all these structures is not well understood. The coupling denticles would increase the frictional grip of the male antennule on the juvenile female, but the function of the ventral blade is less obvious. Clearly it is not essential for coupling for it is absent from some species. The antennule of juvenile males (Fig. 32B) is short, thick and its distal segments are not modified for clasping, consequently it would be impossible for juvenile males to couple with females. Transformation of the antennule to a prehensile organ occurs at the metamorphosis from stage V to adult. Adult males couple with stage III, IV and V female copepodites by clasping the posterior region of the body. Segments 1, 2 and the compound segment of the male's antennules lie above the last metasomal segment, urosome and caudal rami of the juvenile female, but the terminal segment of the antennule folds under to grip the female ventrally. A C-shaped epimeral lobe of stage III and IV females or a gap between the epimeral lobe and the P5 of stage V, provides a notch into which the male antennule can lock.

Homologies of the setae and coupling denticles can be inferred from a study of the juvenile stages. Six segments can be discerned in the juvenile female antennule with a prominent  $\delta$  seta and a group of seven setae ( $\pi$  series) on the third segment (Fig. 32A). On segment 4 there is a sensory lobe bearing  $\sigma$  + aesthetasc. Male stage IV and V juveniles, on the other hand, only have five segments; the third bearing  $\delta$ , the  $\pi$  series and the sensory lobe with  $\sigma$  + aesthete (Fig. 32B). This segment must represent the fusion of 3 and 4; the same condition that is found in the transformed (metamorphosed) male antennule.

Although there is a close correspondence between the setation of juvenile and adult male antennules, there is nothing in the juvenile that corresponds to the coupling denticles and ventral blade; these structures cannot represent modified setae and must arise *de novo* at the time of metamorphosis as sclerotisation of

special areas of the antennule integument.

The coupling denticles show a high degree of specificity and clearly distinguish species, but their practical value in identification is limited if they are obscured by the terminal segment of the antennule. Their value in defining genera is less certain. Denticulate pads (Figs 14A, 18F, 31) have not been found in any members of *Porcellidium*. They occur in *Murramia* but are not exclusive to that genus. Similarly the shape and presence of the ventral blade, although highly specific, does not show a clear distinction between genera. It is, for example, present in some species of *Porcellidium* (*sensu* Harris & Robertson, 1994), but not in others, moreover, there is a continuous range of shapes from a small incipient blade to one as long as the compound segment. At this stage in our understanding of Porcellidid taxonomy it is best to regard antennule structure as providing valuable taxonomic characters at the specific level only.

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*Pachycerianthus*  
(Anthozoa: Ceriantharia: Cerianthidae),  
Two Newly Described Species from  
Port Jackson, Australia

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**ABSTRACT.** Two previously undescribed species of *Pachycerianthus* from Port Jackson are described. The species can be easily distinguished in the field on appearance. *Pachycerianthus delwynae* has distinctly banded marginal tentacles. *Pachycerianthus longistriatus* has distinctive longitudinal stripes on its marginals. Both species are found in sublittoral sandy mud in Port Jackson, often in close association with each other.

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Cerianthids are attenuated, solitary anemone-like anthozoans (Fig. 1a) with two series of tentacles in the crown and no pedal disc, which inhabit a soft tube made of layers of discarded nematocysts, sometimes encrusted with mud or sand (den Hartog, 1977).

Although cerianthids are considered common members of the benthic fauna of south-eastern Australia (Coleman, 1987; Shepherd & Thomas, 1982), knowledge of the taxonomy and morphology of Australian species is very poor. They have usually been designated as *Cerianthus* sp. or *Cerianthus membranaceus* (Spallanzani), a Mediterranean species. There are four genera in the family Cerianthidae, *Cerianthus* Delle Chiaje, *Pachycerianthus* Roule, *Ceriantheopsis* Carlgren and *Ceriantheomorphe* Carlgren. The two species now described from Port Jackson, NSW, are

assigned to the genus *Pachycerianthus*. This distinction is based on the presence of short, sterile mesenteries at m1 and b1 whereas *Cerianthus*, *Ceriantheopsis* and *Ceriantheomorphe* have fertile m1 and b1 mesenteries (Carlgren, 1912, 1931).

#### Materials and Methods

All animals were collected from Port Jackson by SCUBA diving. They were dug from the silt by hand and transported live to the Taronga Zoo Aquarium where they were placed in a 200 litre glass aquarium with fresh seawater flowing through at about five litres/minute.

Specimens were removed from their tubes and anaesthetised using MS222 (1g/litre), then fixed in 20% formalin buffered with excess hydrated magnesium sulphate. After fixing they were stored in 10% formalin solution, buffered with sea water. Contraction occurred during preservation, especially of the marginal tentacles.

Cnida were studied from paratype specimens from the collection of the Australian Museum. Wet squash preparations were made and studied under an interference contrast microscope using a magnification of  $800\times$  (oil immersion  $100\times$ , ocular  $8\times$ ). Measurements were made with an ocular micrometer. Descriptions of the cnida and anatomy are based on those of den Hartog (1977).

A series of specimens, including the type material, has been deposited in the collection of the Australian Museum, Sydney.

Subclass: *Ceriantipatharia* van Beneden, 1898

Order: *Ceriantharia* Perrier

Suborder: *Spirularia* den Hartog, 1977

Family: *Cerianthidae* Milne-Edwards & Haime, 1852

Genus: *Pachycerianthus* Roule, 1904

*Pachycerianthus delwynae* n.sp.

**Type material.** HOLOTYPE: Port Jackson, Chowder Bay, muddy sand, 14 m, coll. S. Carter, 15 September 1989, AMG15399. PARATYPES (2 specimens): Port Jackson, Bottle & Glass Rocks, sandy mud, 5 m, coll. P. Watts, 13 July 1989, AMG15400; Bottle & Glass Rocks, amongst mussel shell debris, 7 m, coll. S. Carter, 20 July 1989, AMG15401. Additional material (1 specimen): Port Jackson, Manly pool, coll. Dr P. Groves, 31 December 1957, AMG15404.

**Description.** *Coloration of live animals.* Column purplish brown aborally, merging through dark to pale yellowish brown to dark brown just below oral disc. Marginal tentacles pale orange to reddish brown with indistinct pale or white bands. Labial tentacles pale yellowish brown to cream colour. The oral disc is purplish brown.

*Coloration of preserved animals.* Purple colour faded leaving overall brown coloration. Marginal tentacles still possess distinct pale bands. Labials are pale yellowish brown.

*Length in preservative.* 50–240 mm.

*Tentacles.* Formula for arrangement of tentacles into pseudocycles are: marginal tentacles, 1(dt)2314.2314.2314...; labial tentacles, 2(dt)413.4231.4312.4312... or 1(dt)341.4231.4312... In each crown, division into pseudo-cycles is difficult in some specimens. Directive labial tentacle (dt) is present. Marginal tentacles number 89–114 (type 110). Labial tentacles number 89–112. When animal not actively feeding, but still extended from tube, distal half to one third of marginal tentacles hang limply with distal

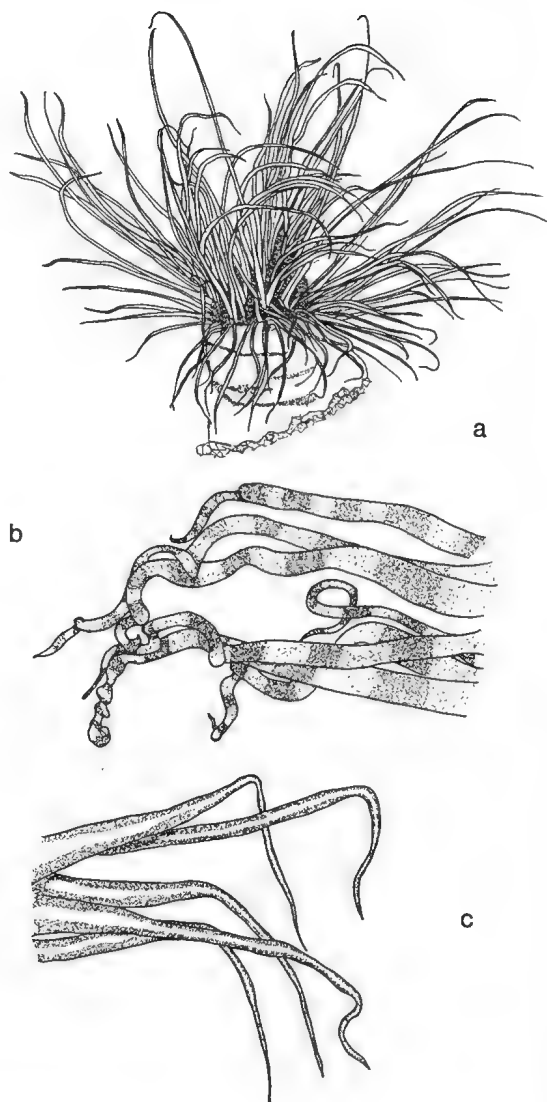


Fig. 1. a – Generalised view of organism; b – *Pachycerianthus delwynae* showing distinctive markings and coiled tentacles; c – *Pachycerianthus longistriatus* showing distinctive markings on the tentacles.

quarter coiled loosely. This distal quarter remains coiled when animal withdraws into its tube.

*Siphonoglyph.* Running two-thirds length of actinopharynx. Attached mesenteries 6 or 7 (7 in type). Hyposulcus well developed, reaching one fifth length of siphonoglyph. Hemisulcus distinct, continuing down directive tentacle.

*Mesenteries.* Directive mesenteries (B1) shorter than siphonoglyph; lengths of mesenteries may differ in same animal. Second mesenteries (m1) sterile, more than twice length of directives. Ciliated tract runs whole length of m1 and a few craspedonemes occupy aboral end. Third mesentery (b1) sterile,  $1\text{--}1.5\times$  length of m1. Cnidoglandular tract found on distal half, a few craspedonemes may be present on distal end of b1 mesentery.

Mesenterial arrangement is BmbM. All macro-mesenteries (M, m) fertile, all micromesenteries (B, b) infertile. M1 long, but never reaches aboral pole. Three quarters to all of M1 occupied by ciliated tract and distal three quarters possess craspedonemes. The m1 mesenteries less than half length of M1 with ciliated tract running length of mesentery, distal half with craspedonemes. M2 longer or shorter than M1 and may reach aboral pole. Ciliated tract occupies nearly entire length of M2. After second quartette, M mesenteries reduced in length toward reproductive chamber, m mesenteries all of similar length. Micromesenteries usually very short. B1 usually similar in length to directive mesentery with b1 being half the length of B1. All the micromesenteries carry considerable amounts of cnidoglandular tract. After second quartette, micromesenteries vary little in length (Fig. 2).

**Cnidom.** Spirocysts, atrichs, homotrichs and spirulae of several types are present. The measurements were taken from 20 cnida for each type from three samples (n = 60) from two paratype specimens. All cnida are considered numerous and common unless specified.

	Length (range)		Width (range) mm
<b>Marginals</b>			
Spirocysts	48.1 (34.4–56.2)	×	5.6 (3.1–9.4)
Spirula 2	65.6 (59.3–75.0)	×	8.4 (6.3–9.4)
Spirula	26.6 (25.0–28.1)	×	2.4 (1.6–3.1)
Atrich (uncommon)	59.4 (51.6–68.8)	×	7.8 (4.7–9.4)
<b>Column</b>			
Homotrich	53.1 (46.9–62.5)	×	15.9 (7.8–21.9)
Atrich	36.9 (25.0–46.9)	×	10.9 (4.7–21.9)
Spirula 2	42.2 (40.6–43.8)	×	5.0 (3.1–6.3)
Spirula 2	45.3 (40.6–50.0)	×	7.8 (6.3–9.4)
<b>Labials</b>			
Spirula 2	53.1 (50.0–54.2)	×	7.8 (6.3–9.4)
Spirocyst	43.4 (25.0–53.1)	×	5.6 (1.6–9.4)
Atrich (uncommon)	32.2 (25.0–40.6)	×	9.4 (6.2–12.5)
Spirula 2	35.3 (31.2–37.5)	×	5.6 (4.7–6.3)
<b>Craspedonemes</b>			
Atrich	62.5 (43.8–71.9)	×	19.7 (9.4–25.0)
Spirula 2	51.6 (43.8–68.8)	×	8.6 (7.8–9.4)
Spirocyst	24.1 (21.9–28.2)	×	3.8 (3.1–4.7)
Spirula 2	41.2 (37.5–46.9)	×	6.3 (3.1–9.4)
<b>Simple Chord</b>			
Spirula 2	28.1 (25.0–31.3)	×	7.8 (6.3–9.4)
Spirocyst	37.5 (36.1–39.2)	×	4.7 (4.0–5.1)
Spirula 2	26.3 (25.0–28.1)	×	6.3 (6.3–9.4)
<b>Actinopharynx</b>			
Spirula 2	45.9 (43.8–46.9)	×	7.2 (6.3–7.8)
Atrich	50.9 (40.6–68.8)	×	13.4 (6.3–25.0)
Spirula 2	31.0 (25.4–33.8)	×	4.7 (3.2–5.0)

Spirocysts appear to be absent from the column and the actinopharynx. The classes of spirulae could be separated on the length of the shaft in relation to the total capsule length. Spirulae 2 is the most common type, found in all tissue except the single chord of

filament. Atrichs were found in all organs except the single chord and were uncommon in the labial and marginal tentacle tips. Homotrichs appear to be confined to the column.

**Biology.** Specimens were all collected from, or observed in, sand and/or muddy sediments, often with overlying banks of mussel shell (*Mytilus* sp) detritus or among parchment worm (*Diopatra dentata*) colonies. Depth range varied from three to over 15 m. The tubes rarely protruded more than three centimeters above the substrate. Several specimens have been collected with large numbers of the commensal worm, *Phoronis australis*, living in the tube walls. Coleman (1987) reported the presence of a commensal shrimp *Periclemenes holthuisi* and crab *Lissocarcinus* sp in association with an unidentified cerianthid which appears to be similar to *Pachycerianthus delwyna*.

Specimens viewed in an aquarium or in their natural habitat were rarely active unless light levels were low, suggesting that *P. delwyna* is crepuscular.

**Remarks.** *Pachycerianthus delwyna* possesses a directive labial tentacle, M1 never reaches the aboral pole and M2 may be longer than M1. M mesenteries are much longer than m mesenteries. The distinctive banded marginal tentacles are commonly coiled when relaxed (Fig. 1b). These features distinguish *P. delwyna* from the other known species of *Pachycerianthus*.

**Etymology.** *Pachycerianthus delwyna* is named after Ms Delwyn Hunt for her support and assistance during this study.

### *Pachycerianthus longistriatus* n.sp.

**Type material.** HOLOTYPE: Taylors Bay, Port Jackson, silt over mussel debris, 5 m, coll. P. Watts, 20 July 1989, AMG15402. PARATYPES: Chowder Bay, Port Jackson, silt, 10 m, coll. S. Carter, 15 September 1989, AMG15403; Port Jackson, Old Collection, c. 1886, 1 specimen, AMG12553; Port Jackson, Old Collection, 3 specimens, G12554; Port Jackson, Old Collection, 1 specimen, AMG12555; Dawes Point, Port Jackson, 5–6 fathoms, bucket dredge, coll. W.J. Hale, January 1933, AM G13558–G13561; Drummoyne, 3 August 1963, 2 specimens, AMG15405; off Dawes Point, Port Jackson, 1933, coll. W.J. Hale, AMG15406.

**Description.** *Coloration of live animals.* Column purple aborally merging to brown orally. Brown coloration may vary from dark to pale yellowish brown. Marginal tentacles all have a pale longitudinal stripe on each side with oral and aboral faces coloured, which gives them a distinctly striped appearance. Two tentacle colour forms: one pale yellowish brown the other deep purplish maroon. Labial tentacles pale cream. Oral disc deep brown in colour.

*Coloration of preserved animals.* Purple colour faded leaving column brown overall. Marginal tentacles, of the pale yellowish-brown colour form, fade to a pale cream, leaving stripes faintly visible. Maroon form retains faded purplish coloration. Labial tentacles almost white.

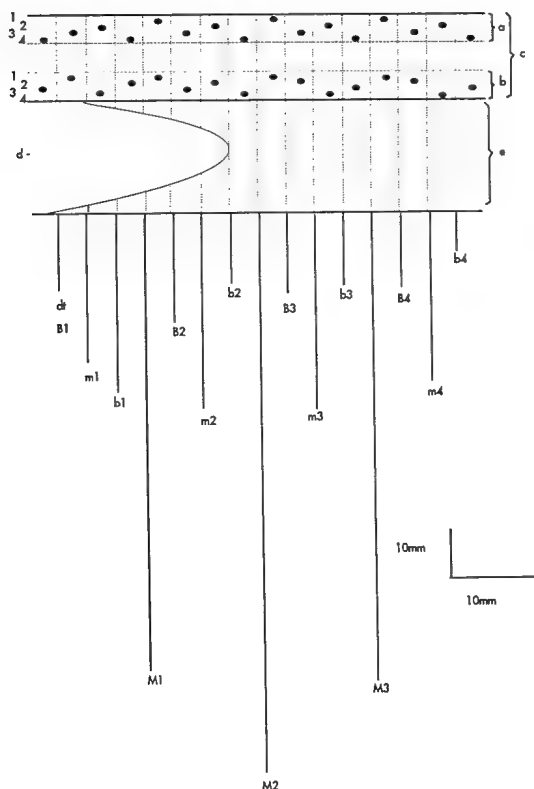


Fig. 2. Diagrammatic representation showing the right half of the internal arrangement of *Pachycerianthus delwynae*, cut longitudinally and pinned flat. a – marginal tentacle bases, b – labial tentacle bases, c – oral disc, d – siphonoglyph, e – actinopharynx, f – hemisulcus, g – protomesenteries, h – first quartette of metamesenteries.

*Length in preservative.* 70–220 mm.

*Tentacles.* Arrangement of tentacles in pseudocycles: marginal tentacles, 2(dt)431.4231.4231...; labial tentacles, 3(dt)241.4231.4231... cycles 2 and 3 very difficult to separate. Directive labial tentacle present. Marginal tentacles number 138–140 (type 140), labial tentacles number 130–139 (type 138). Some marginal tentacles may be damaged at some time during animal's life and during regeneration a second tentacle may develop from a single tentacle base. When not actively feeding or in still water, distal third of marginal tentacles hang limply (Fig. 1c).

*Siphonoglyph.* Runs complete length of actinopharynx. Six attached mesenteries. Hyposulcus well developed, reaching one fifth length of siphonoglyph. Hemisulcus distinct but short.

*Mesenteries.* The directive mesenteries (B1) are short and may differ in length; m1 sterile, 1.5–3 × length of directives. Ciliated tract runs entire length of m1, craspedonemes may be present at distal end; b1 is 1–1.5 × length of m1. Ciliated tract runs entire length of

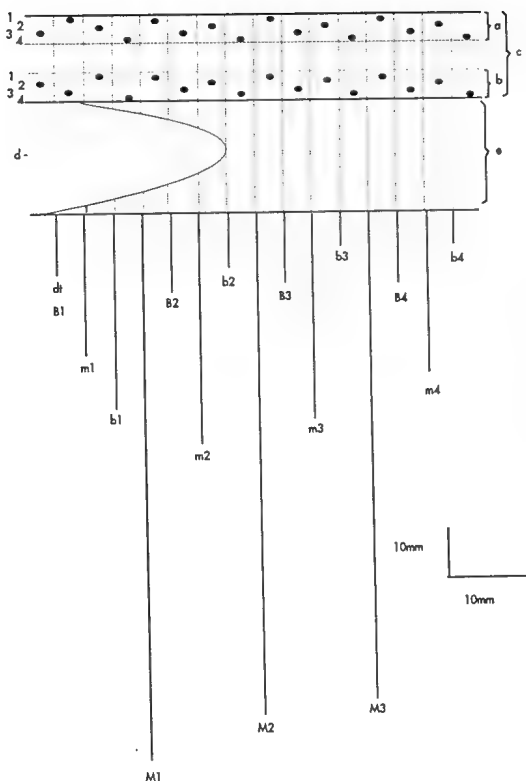


Fig. 3. Diagrammatic representation showing the right half of the internal arrangement of *Pachycerianthus longistriatus*, cut longitudinally and pinned flat. For explanation of key, see Figure 2.

b1, craspedonemes may be present along distal half and cnidoglandular tract may be found at aboral tip of mesentery.

*Mesenterial arrangement BmbM.* All macromesenteries (M, m), except m1, are fertile, all micromesenteries (B, b) infertile. M1 long, reaching to aboral pole. M2 and M3 also long, almost reaching to aboral pole. Half to two-thirds of M1 occupied by ciliated tract and distal three-quarters carries craspedonemes. The m1 mesenteries less than half length of M1, ciliated tract confined to proximal three-quarters. Slight reduction in length of m mesenteries as they approach multiplication chamber. M mesenteries undergo substantial reduction in length after second quartette. Micromesenteries generally very short, B mesenteries twice length of b. All micromesenteries possess cnidoglandular tract. After first quartette, micromesenteries vary little in length (Fig. 3).

*Cnidom.* Spirocysts, spirulae, atrichs and homotrichs are present. Cnida were examined and measured in two paratype specimens with ten capsules of each type measured from three samples (n = 60).

	Length (range)		Width (range) mm	
<b>Marginals</b>				
Spirocyst	44.1 (21.9–60.9)	×	5.3 (1.6–9.4)	
Spirula 2	53.1 (50.0–56.3)	×	5.9 (4.7–6.3)	
Spirula 2	52.2 (46.9–56.3)	×	8.4 (7.8–9.4)	
Spirula 1	32.8 (31.3–34.4)	×	5.5 (4.7–6.3)	
<b>Column</b>				
Homotrich	48.4 (46.9–50.5)	×	15.6 (15.6–16.5)	
Atrich	71.9 (56.3–90.1)	×	25.3 (15.6–31.3)	
Atrich	40.0 (37.5–43.8)	×	5.3 (3.2–6.4)	
Spirula 2	27.2 (25.0–28.2)	×	5.3 (4.7–6.3)	
Spirula 2	36.5 (34.4–37.5)	×	7.8 (6.3–9.4)	
<b>Labials</b>				
Spirula 2	43.8 (31.3–53.2)	×	10.3 (7.8–12.5)	
Spirocyst	41.1 (29.7–53.2)	×	4.4 (1.6–7.8)	
Atrich (uncommon)	37.5 (28.1–40.6)	×	7.5 (6.3–9.4)	
Spirula 2	35.9 (34.4–37.5)	×	4.7 (3.2–6.3)	
<b>Craspedonemes</b>				
Atrich	43.8 (37.5–53.1)	×	6.3 (4.7–9.4)	
Spirula 2	32.2 (28.1–37.5)	×	6.3 (4.7–7.8)	
Spirocyst	30.0 (18.9–37.5)	×	5.3 (3.2–7.8)	
<b>Simple Chord</b>				
Atrich	36.3 (34.4–37.5)	×	5.3 (3.2–6.3)	
Spirocyst	45.6 (37.5–56.3)	×	4.1 (1.6–6.3)	
Spirula 2	44.3 (37.5–53.1)	×	6.3 (4.7–9.4)	
<b>Actinopharynx</b>				
Atrich	43.8 (40.6–46.9)	×	5.9 (3.1–7.8)	
Spirocyst	52.5 (46.9–59.4)	×	5.3 (3.1–7.8)	
Spirula 2	42.5 (37.5–46.9)	×	5.0 (3.1–7.8)	
Spirula 2	33.1 (28.1–37.5)	×	4.4 (3.1–6.3)	

Atrichs are absent in the marginal tentacles and uncommon in the labial tentacles and homotrichs are confined to the column. Spirocysts were found in all organs except the column. Spirulae classes were generally restricted to two, with type 2 spirulae the most common in all tissues except the simple chord in the filaments.

**Biology.** This species occupies the same habitat as *P. delwynae*, often living in close proximity. Similar commensal organisms are found associated with both species. One specimen has been kept on display at Taronga Aquarium for 21 years, during which time it has once produced offspring (J. West, pers. comm.), unfortunately the method of reproduction was not reported.

**Remarks.** *Pachycerianthus longistriatus* has M1 reaching the aboral pole, M2 and M3 almost reaching the aboral pole and m1 only being half the length of M1. A directive labial tentacle is present. M1 mesentery is short. These stable characters distinguish *P. longistriatus* from other species of *Pachycerianthus*.

**Etymology.** The specific name *longistriatus* describes the longitudinal stripes on the marginal tentacles (Fig. 1c).

## Discussion

There are now 14 known species of *Pachycerianthus* (Arai, 1965; den Hartog, 1977; Uchida, 1979) (Table 1).

*Pachycerianthus delwynae* n.sp. and *P. longistriatus* n.sp. can easily be separated from each other on external appearance.

*Pachycerianthus delwynae* has distinctive white or pale bands on pale orange to reddish brown marginal tentacles which, when relaxed, become coiled at the tips. The distinctive coiling at the tips was also reported in *Arachnanthus nocturnus* (den Hartog, 1977) and explained as a reaction to photoflash and Arai (1972) induced the response in *P. fimbriatus* by tactile stimulus. However, continual daily observations of *P. delwynae* under different light conditions in aquaria and regular observation of specimens in the field over a two year period leads to the acceptance of the coiling of the tentacle tips as a normal behaviour. At no time during the same period was *P. longistriatus* observed with coiled tentacles.

*Pachycerianthus longistriatus* has distinct stripes along the length of the marginal tentacles, which range in colour from a soft pale yellowish brown to a deep purple maroon. The sides of the tentacles are usually paler in colour.

In both species the coloration of the tentacles is consistent in all specimens collected and in several observed in the field but not collected.

In *P. delwynae*, M2 may be longer than M1 and M1 does not reach the aboral pole. In *P. longistriatus*, M1 reaches the aboral pole and M2 and M3 mesenteries are almost as long as M1. *Pachycerianthus delwynae* has m mesenteries less than half the length of M mesenteries and *P. longistriatus* has m mesenteries half the length of M mesenteries. Both species possess a labial directive tentacle and m1 is short in both (Table 1), between 1.5–3.0 × the length of the directive tentacle.

*Pachycerianthus delwynae* and *P. longistriatus* are similar to five described species of *Pachycerianthus*, *P. aestuari* (Torrey & Kleeberger, 1909), *P. fimbriatus* McMurrich, 1910 (= *P. plicatus* Carlgren, 1924), *P. magnus* (Nakamoto, 1919), *P. monostichus* McMurrich, 1910 and *P. solitarius* (Rapp, 1829) (= *P. bicyclus* [Torelli, 1961]) in having a labial directive tentacle (Table 1). Of these, *P. aestuari* and *P. solitarius* differ in having m mesenteries of almost the same length as the M mesenteries, whereas, in both of the new species they are less than half the length. *Pachycerianthus fimbriatus*, *P. curacaoensis* den Hartog, 1977 and *P. magnus* differ from both of the new species in having M1 mesenteries much longer than all other M mesenteries. In *P. delwynae*, M2 is longer than M1 and in *P. longistriatus* M2 is almost as long as M1. *Pachycerianthus longistriatus* also has only six attached mesenteries where *P. fimbriatus* has 8–12. The remaining species with a labial directive tentacle, *P. monostichus*, has a very long m1 mesentery and the marginal tentacles are arranged in two pseudocycles as opposed to short m1

mesenteries and four pseudocycles of marginal tentacles in the two new species.

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Table 1. Comparison of characters of some species of *Pachycerianthus*.

Species	dt B1	M1 length	M2 length	m1 length	m2 length	Attached mesentery	siphonoglyph
<i>aestuaria</i>	yes	to aboral		v.short	= M	16	v.broad
<i>benedeni</i>	no	to aboral	<<M1	short	short		v.broad
<i>curacaoensis</i>	yes	to aboral	< <sup>1</sup> / <sub>2</sub> M1	long	< m1		narrow
<i>delwynae</i> n.sp.	yes	~to aboral	> M1	short	< <sup>1</sup> / <sub>2</sub> M	6, 7	narrow
<i>dorhni</i>	no			long			
<i>fimbriatus</i>	yes	to aboral	<<M1	short	<sup>1</sup> / <sub>3</sub> M	8, 10–12	broad
<i>insignis</i>	no	~to aboral	= M1		= M		
<i>johnsoni</i>	no	to aboral	<<M1		short	8	broad
<i>longistriatus</i> n.sp.	yes	to aboral	= M1	short	< <sup>1</sup> / <sub>2</sub> M1	6	broad
<i>magnus</i>	yes	not to aboral	<sup>1</sup> / <sub>2</sub> M1	short	<sup>1</sup> / <sub>2</sub> M1	6	narrow
<i>maua</i>	no	~to aboral	<<M1	short	short	6	narrow
<i>monostichus</i>	yes	to aboral	< M1	v.long		0	broad
<i>multiplicatus</i>	no	to aboral	= M1	short	= P2	6	narrow
<i>solitarius</i>	yes	to aboral	≅ M1	short	= M	6	broad

## New Lysianassoid Genera and Species from South-eastern Australia (Crustacea: Amphipoda)

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**ABSTRACT.** Two new lysianassoid genera and species (*Gippsia jonesae* and *Thaumodon poorei*) are described from south-eastern Australia. The poorly known genus *Galathella* Barnard & Karaman, 1987, is rediagnosed; two new species (*G. bassiana* and *G. palana*) from south-eastern Australia are described and *G. latipes* (Ledoyer, 1986) from the western Indian Ocean is included. *Galathella* appears to be most closely related to *Centromedon* Sars, 1891, *Gippsia* n.gen. appears to be most closely related to *Ichnopus* Costa, 1853 and *Thaumodon* n.gen. appears to be related to *Concarnes* Barnard & Karaman, 1991.

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As part of our studies revising the world lysianassoid genera we describe two new genera, *Gippsia* and *Thaumodon*, from south-eastern Australia and redescribe the poorly known genus *Galathella* Barnard & Karaman, 1987, based on examination of the original material and new material from deep water near Bass Strait.

*Thaumodon* belongs in the Lysianassidae. The Lysianassidae comprises taxa with a palp on maxilla 1 and a 6/5 setal-tooth arrangement on the outer plate of maxilla 1. The 6/5 arrangement may be derived from a simple 7/4 arrangement (Fig. 1a) in which eleven distal setal-teeth on the outer plate of maxilla 1 occur in two rows, an apical row of seven setal-teeth (known as ST1 to ST7) and a subapical row of four setal-teeth (known as STA to STD). In the 6/5 arrangement (Fig. 1b) the outer plate becomes slightly narrowed apically so that setal-tooth 1 (ST1) is displaced downwards, which displaces setal-tooth A (STA). This causes STA

to be slightly displaced from STB. More than 60 lysianassoid genera in three family groups have this setal-tooth arrangement. The new genus *Thaumodon* has a modified 6/5 arrangement (Fig. 1c). Setal-tooth 7 is displaced from the outer row so that it sits against STD on the inner row. This has compressed the inner row setal-teeth so that STC is touching STA and STB is pushed behind them. To add to their unusual appearance the inner row setal-teeth are large and all of the setal-teeth are cornified, curved and without cusps.

*Thaumodon* occurs among seagrasses and wharf pilings and although it resembles a typical lysianassid, the simple first gnathopods are modified into a rasping organ and the mouthpart morphology is highly derived. Nothing is known about the ecology or behaviour of this species, but such information would be valuable in helping to interpret the interesting mouthpart morphology.



*Galathella* and *Gippsia* belong to the family Uristidae as defined by Lowry & Stoddart (1992) as taxa in which the setal-teeth on the outer plate of maxilla 1 have a 7/4 crown arrangement. The 7/4 crown arrangement is most likely derived from the 6/5 arrangement through a further apical narrowing of the outer plate. The narrowing of the plate displaces setal-tooth 7 (ST7) down the medial face (Fig. 1d). The migration of ST7 can be traced from a position opposite STD in *Kyska* Shoemaker, 1964, to a position beyond STD in *Anonyx* Krøyer, 1838 and *Ichnopus* Costa, 1853. The 7/4 crown arrangement may have arisen more than once, but at this stage it is not possible to detect separate lineages.

*Galathella galatheae* (Dahl, 1959) was originally described in the genus *Schisturella* Norman, 1900, based on one female specimen from the Kermadec Trench. Barnard & Karaman (1987) established a monotypic genus, *Galathella*, for this species based on rather slim differences from *Schisturella*: an unproduced upper lip and a non-constricted inner ramus on uropod 2 (referred to as uropod 3 in Barnard & Karaman, 1987 and 1991). In fact *Galathella* differs from *Schisturella* in the arrangement of the setal-teeth on the outer plate of maxilla 1 and the first coxa is reduced and tapering, not vestigial as it is in *Schisturella*. New material of *Galathella* from mud bottoms on the continental slope and abyssal plain adjacent to the Bass Strait has allowed us to describe the genus more fully and re-evaluate its relationships with other lysianassooid genera.

The genus *Gippsia* was collected from shallow coarse sand bottoms in south-eastern Australia. It appears to be related to the uristid genus *Ichnopus* but the simple dactylus on gnathopod 1, the shortened outer plate of maxilla 2 and the entire telson distinguish it from this genus. Because of the arrangement of the setal-teeth on maxilla 1, particularly the position of setal-tooth 7 and the setose molar with a very reduced triturating surface, species of *Galathella* and *Gippsia* are considered to be scavengers and/or predators.

In this paper we change the terminology we have previously used to describe setae and spines. This change is based primarily on arguments about the homology of setae and spines presented by Oshel & Steele (1988) and Watling (1989). The terminology mainly follows Watling (1989) with a few modifications. What we have previously referred to as setae are now referred to as slender setae and what we previously referred to as spines are now called robust setae. What we previously referred to mainly as teeth (non-articulating extrusions of the cuticle), are now referred to as spines.

Descriptions have been generated from the taxonomic database program DELTA (Dallwitz & Paine, 1986). All material is lodged in the Australian Museum, Sydney (AM) or the Museum of Victoria, Melbourne (NMV). The following abbreviations are used on the plates: A, antenna; E, epistome and upper lip; EP, epimeron; G, gnathopod; H, head; MD, mandible; MDP, mandibular palp; MP, maxilliped; MPIP, maxilliped inner plate; MPOP, maxilliped

outer plate; MPP, maxilliped palp; MX, maxilla; P, peraeopod; ST, setal-tooth; T, telson; U, uropod; UR, urosome; l, left; r, right; lat, lateral.

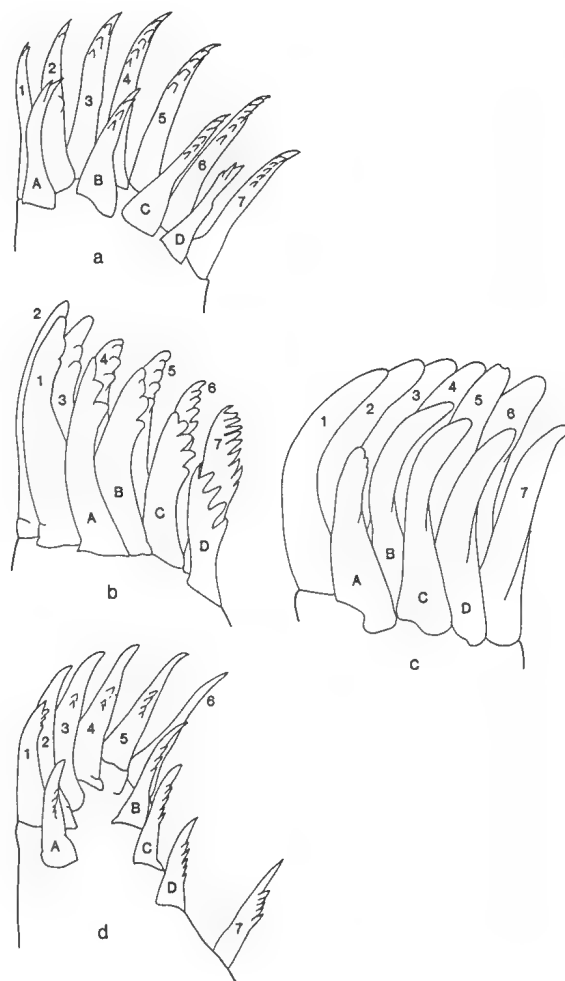


Fig. 1. Setal-teeth of maxilla 1 outer plate. a – 7/4 arrangement; b – 6/5 arrangement; c – modified 6/5 arrangement of *Thaumodon*; d – 7/4 crown arrangement.

## Systematics

### Lysianassoidea

#### Lysianassidae

#### *Thaumodon* n.gen.

**Diagnosis.** Antenna 1: female without callynophore, male with weak 1-field callynophore. Antenna 2: peduncular articles 4 and 5 not enlarged in male, flagellum not elongate in male. Mandible: incisors symmetrical, extremely enlarged, both with slightly convex margins; lacinia mobilis absent; accessory setal row present; molar a reduced setose flap; mandibular palp attached extremely proximally. Maxilla 1: outer

plate narrow, with 11 setal-teeth, ST1 to ST7 large, strongly curved, without cusps, ST7 displaced onto inner row; STA to STD compressed, large, strongly curved, without cusps, STB compressed between STA and STC; palp with serrate apical margin. Maxilliped: inner plate with 3 greatly elongate apical setae. Gnathopod 1: simple; dactylus short, rasp-like with a medial row of large teeth and several medial rows of smaller teeth. Peraeopods 3 and 4 in male, merus and carpus with plumose setae along posterior margin. Uropod 3: peduncle short with strongly developed lateral flange; male peduncle and rami with plumose setae. Telson slightly longer than broad, moderately cleft (50%).

**Type species.** *Thaumodon poorei* n.sp.

**Species composition.** *Thaumodon* contains only *T. poorei* n.sp.

**Etymology.** From the Greek nouns *thauma* meaning marvel and *odon* meaning tooth.

**Remarks.** *Thaumodon* is most similar to *Concarnes* Barnard & Karaman, 1991. They share characters such as the long slender accessory setae, reduced molar, proximal mandibular palp, strong, curved setal-teeth and distally serrate palp of maxilla 1, lack of setae on the outer plate of the maxilliped, simple gnathopod 1 and moderately cleft telson. They differ in that *Thaumodon* has a sexually dimorphic gnathopod 2, a 1-articulate outer ramus on uropod 3 and none of the typical male secondary sexual characters (such as large eyes, callynophore, calceoli, long antenna 2 and plumose setae on uropod 3).

*Thaumodon* shows some similarity to *Pseudonesimoides* Bellan-Santini & Ledoyer, 1974, in the greatly enlarged mandibular incisor, the reduced molar, the large curved setal-teeth of maxilla 1 and the enlarged apical setae on the inner plate of the maxilliped. However, in other significant characters, such as the chelation of gnathopod 1 and the spination of the inner and outer plates of the maxilliped, these two genera are extremely different.

*Thaumodon* is distinguished from both these taxa by the setal-teeth of maxilla 1, the apical setae on the inner plate of the maxilliped and the rasp-like dactylus on gnathopod 1.

### *Thaumodon poorei* n.sp.

Figs 2, 3

**Type material.** HOLOTYPE, female, 14 mm, NMV J25814, 1 PARATYPE, male, 11.5 mm, NMV J3787 and 3 PARATYPES, female, AM P40431: off Crib Point, Western Port, Victoria, Australia, 38°21'S 145°14'E, Smith-McIntyre grab, weed and mud, 7 m, A.J. Gilmour and Marine Studies Group on FV *Melita*, 4 September 1964, stn CPBS-B1. PARATYPE female, NMV J3786, Crawfish Rock, Western Port, Victoria, Australia, Underwater Research Group, 10 November 1968. 4

PARATYPES, NMV J3788, Tankerton Jetty, Western Port, Victoria, 6 m, Underwater Research Group, 22 November 1970.

**Description.** Based on holotype female, 14 mm and paratype male, 11.5 mm. *Head and body:* with scattered setae. *Head:* deeper than long, lateral cephalic lobe large, broad, distally truncated; rostrum absent; eyes oval, not enlarged in adult male. *Antenna 1:* short,  $0.14 \times$  body; peduncular article 1 short, length  $1.4 \times$  breadth, with small midmedial spine; peduncular article 2 short,  $0.46 \times$  article 1; peduncular article 3 long,  $0.25 \times$  article 1; accessory flagellum long,  $0.7 \times$  primary flagellum, 6-articulate, article 1 short,  $1.2 \times$  article 2 (male short,  $1.4 \times$ ); flagellum 9-articulate (male 9), without callynophore in female (weak 1-field callynophore in male), without flagellar robust setae, calceoli absent in female and male. *Antenna 2:* subequal in length to antenna 1 in female and male; peduncle without brush setae in female or male, weakly geniculate between peduncular articles 3–4, article 3 short, peduncular articles 4 and 5 not enlarged in female or male; flagellum 8-articulate (male 7), calceoli absent in female and male.

*Mouthpart bundle:* subquadrate. *Epistome* and *upper lip:* separate, epistome slightly produced, rounded, upper lip slightly produced, rounded. *Mandible:* incisors symmetrical, very large, with slightly convex margins; lacinia mobilis absent; accessory setal row, left and right rows each with 3 long, slender, simple setae; intermediate setae absent; molar a reduced finely setose flap; mandibular palp attached extremely proximally; article 1 short, length  $1.6 \times$  breadth; article 2 slender, length  $5.8 \times$  breadth,  $2 \times$  article 3, with 8 distal A2-setae, without D2-setae; article 3 slender, blade-like, long, length  $3.75 \times$  breadth, without A3-setae, without D3-setae (male 3), with 3 apical E3-setae. *Maxilla 1:* inner plate narrow, with 2 pappose setae; outer plate with 11 setal-teeth in modified 6/5 arrangement, setal-teeth without cusps, ST1 to ST7 large, slender, curved, smooth, without cusps, ST7 contiguous with ST6; STA large, slender, curved, slightly displaced from STB and contiguous with STC, STB large, slender, curved, without cusps, STC large, slender, curved, slightly displaced from STB and contiguous with STA and STD, without cusps, STD large, slender, curved, contiguous with STB-STC and ST7, without cusps; palp large, 2-articulate, with serrate apical margin, without subterminal setae, robust flag seta present on distolateral corner, distomedial margin serrate. *Maxilla 2:* inner plate broad, outer plate narrow, inner plate length  $1 \times$  outer plate. *Maxilliped:* inner plate large, subrectangular, with 3 apical long robust setae, oblique setal row reduced with 3 simple setae; outer plate medium size, subovate, without apical slender setae, without apical robust setae, medial setae absent, submarginal setae vestigial; palp large, 4-articulate, article 2 slender, length  $2.3 \times$  breadth, article 3 long, slender, dactylus reduced, with 2 terminal and 1 subterminal setae, unguis present.

*Gnathopod 1:* simple; coxa large, about as long as



Fig. 2. *Thaumodon poorei* n.gen., n.sp. holotype, female, 14 mm, NMV J25814; whole animal, paratype female, 15 mm, AM P40431; Western Port, Victoria, Australia. Scales represent 0.5 mm.

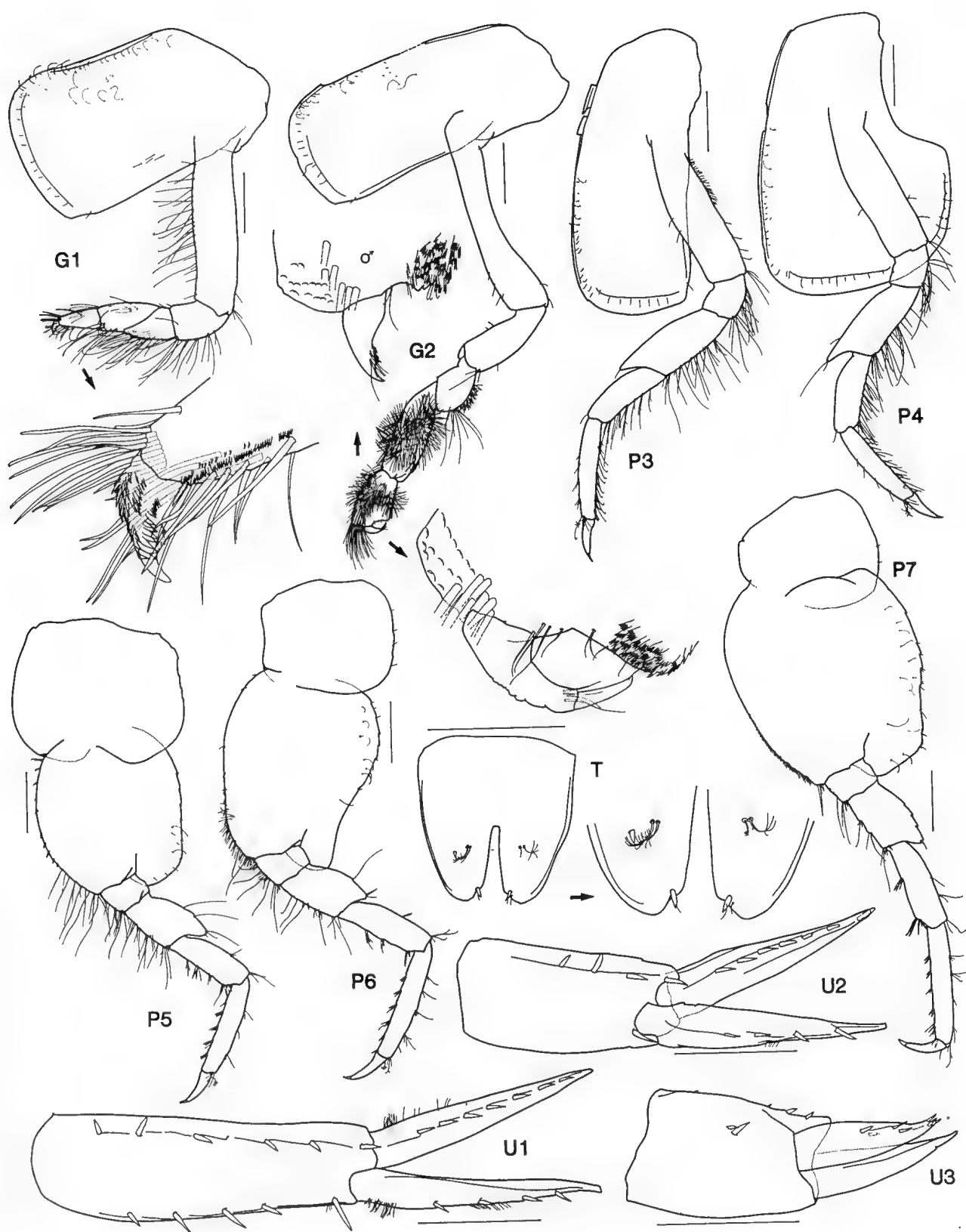


Fig. 3. *Thaumodon poorei* n.gen., n.sp. holotype, female, 14 mm, NMV J25814, paratype male, 11.5 mm, NMV J3787, Western Port, Victoria, Australia. Scales represent 0.5 mm.

coxa 2, anterior margin concave, anteroventral corner produced, rounded, posterior margin straight; basis long, slender, length  $3.9 \times$  breadth, anterior margin smooth, with simple setae; ischium long, length  $1.7 \times$  breadth; merus, posterior margin with long simple setae; carpus subrectangular, long, length  $2.2 \times$  breadth, longer than ( $1.6 \times$ ) propodus, with patch of very fine setae near posterior margin; propodus small, subtriangular, tapering distally, posterior margin serrate, straight, with 4 simple robust setae, palm absent; dactylus rasp-like. *Gnathopod 2*: grossly subchelate in female, minutely subchelate in male; coxa large, subequal in size to coxa 3; ischium long, length  $2.6 \times$  breadth; carpus long, length  $2.8 \times$  breadth, posterior margin straight; propodus subrectangular, short, length  $1.7 \times$  breadth, palm transverse, with concave, smooth margin, posterodistal corner without robust setae; dactylus reaching corner of palm, posterior margin smooth.

*Peraeopod 3*: coxa large; merus-carpus without plumose setae in male and female; propodus with 12 slender setae along posterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 4*: coxa with large posteroventral lobe, anterior margin slightly rounded, posterior margin slightly sloping anteriorly; merus-carpus without plumose setae in male and female; propodus with 12 slender setae along posterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 5*: coxa bilobate, posterior lobe slightly produced ventrally; basis expanded with posterior margin minutely crenate; merus slightly expanded posteriorly; propodus with 10 robust setae along anterior margin, with 1 distal locking seta; dactylus short, slender. *Peraeopod 6*: coxa small, not lobate posteriorly; basis expanded posteriorly with sinusoidal posterior margin; merus slightly expanded posteriorly; propodus with 5 pairs of robust setae along anterior margin, with 1 distal locking seta, with 10 slender setae along posterior margin; dactylus short, slender. *Peraeopod 7*: basis expanded posteriorly, posterior margin almost straight, minutely crenate, posteroventral corner subquadrate, posteroventral margin sloping inward; merus slightly expanded, convex posterior margin with 4 robust setae; propodus with 6 pairs of robust setae and 2 distal locking setae, with 5 groups of slender setae along posterior margin; dactylus short, slender.

*Oostegites*: from gnathopod 2 to peraeopod 5. *Gills*: from gnathopod 2 to peraeopod 6, with strong horizontal pleating.

*Pleonites 1 to 3*: dorsally smooth. *Epimeron 1*: anteroventral corner rounded. *Epimeron 3*: posteroventral corner broadly rounded. *Urosomites*: dorsally smooth. *Uropod 1*: with long fine setae; peduncle with 5 dorsolateral, 1 apicolateral, 4 dorsomedial and 1 apicomедial robust setae; rami subequal in length; outer ramus with 7 lateral robust setae; inner ramus with 4 medial robust setae. *Uropod 2*: with long fine setae; peduncle with 3 dorsolateral, 1 apicolateral and 1 apicomедial robust setae; rami subequal in length; outer ramus with 5 lateral robust setae; inner ramus with 3 lateral and 1 medial robust setae; inner ramus

with weak constriction. *Uropod 3*: peduncle short, length  $1.5 \times$  breadth, with dorsolateral flange, with 5 dorsolateral and 2 dorsomedial robust setae, without midlateral slender or robust setae, without distoventral robust setae, without plumose setae in female or male; rami lanceolate, subequal in length; outer ramus 1-articulate, article 1 without robust setae; inner ramus with 3 lateral and 3 medial robust setae; slender plumose setae absent in female and male. *Telson*: as long as broad, length  $1 \times$  breadth, moderately cleft (49%), with 1 dorsal robust seta on each lobe, without dorsal slender setae, distal margins rounded, with 1 marginal penicillate seta on each lobe, without marginal simple setae, with 1 marginal robust setae on each lobe.

**Etymology.** This species is named for Dr Gary Poore, carcinologist at the Museum of Victoria, in recognition of his exceptional achievements in making known the south-eastern Australian peracaridan fauna.

**Remarks.** The robust, highly cornified mouthparts of *T. poorei* suggest a tough diet such as sponges. The non-cuspidate setal-teeth on the outer plate of maxilla 1 are unusual in lysianassoids. According to Dr W. Rudman (pers. comm.) Australian Museum, dorid opisthobranchs which feed on spiculate sponges have no cusps on their teeth whereas chromodorids, which feed on non-spiculate sponges, have cuspidate teeth.

**Distribution.** *Thaumodon poorei* is currently known only from Western Port, Victoria, south-eastern Australia.

## Uristidae

### *Galathella* Barnard & Karaman

*Galathella* Barnard & Karaman, 1987: 866.—Barnard & Karaman, 1991: 488.

**Diagnosis.** *Head*: lateral cephalic lobe apically rounded. *Antenna 1*: peduncular article 1 without posterodistal tooth; calynophore well developed in female and male, without posterodistal simple or robust setae. Upper lip/epistome separate. *Mandible*: molar setose, with reduced distal triturating surface; mandibular palp with proximal A3-setae, with slender, blade-like article 3. *Maxilla 2*: outer plate longer than inner plate, without extremely elongate setae. *Maxilliped*: outer plate distomedially rounded. *Gnathopod 1*: simple to weakly subchelate; coxa slightly shorter than coxa 2, tapering distally; ischium long, carpus very long. *Peraeopods 3 and 4*: males without plumose setae on posterior margin of merus and carpus. *Epimeron 3*: posteroventrally produced. *Telson*: moderately to deeply cleft.

**Type species.** *Schisturella galatheae* Dahl, 1959, original designation.

**Species composition.** *Galathella* contains *G. bassiana* n.sp., *G. galatheae* (Dahl, 1959), *G. latipes* (Ledoyer, 1986) and *G. palana* n.sp.

**Remarks.** Of those genera with a tapering first coxa only *Centromedon* Sars, 1891 and *Galathella* have a 7/4 crown setal-tooth arrangement on the outer plate of maxilla 1. *Centromedon* differs from *Galathella* as follows: the lateral cephalic lobe is subacute; there is no callynophore in the female; the molar is less developed; the mandibular palp has no proximal A3-setae; and the posteroventral corner of epimeron 3 is produced into a large spine.

Similarities between the two genera are striking. The parallel development of gnathopod 1 within each genus is particularly noticeable. Each genus has species in which gnathopod 1 is simple with long carpus and propodus, weakly subchelate with the palm extremely

acute, or strongly subchelate with nearly transverse palms. Species of *Centromedon* are currently known from northern hemisphere Arctic and temperate regions and lower latitudes in abyssal depths. Species of *Galathella* are currently known from southern hemisphere tropical and temperate regions in shallow to abyssal depths.

All lysianassoid species which have a 7/4 crown setal-tooth arrangement, and for which the life style is known, spend at least part of their life history as scavengers or micropredators (e.g., Dahl, 1979; Sainte-Marie, 1984; Sainte-Marie & Lamarche, 1985; Lowry & Stoddart, 1992). It is therefore highly probable that species in *Galathella* are demersal scavengers and/or micropredators.

**Distribution.** Kermadec Trench (7000 m), south-eastern Australia (600 to 1850 m), south-western Pacific Ocean; Iles Glorieuses, western Indian Ocean (28 m).

### Key to the species of *Galathella*

1. Gnathopod 1 weakly to strongly subchelate ..... 2
- Gnathopod 1 simple ..... *G. palana* n.sp.
2. Telson deeply cleft ..... 3
- Telson moderately cleft, about 45% ..... *G. bassiana* n.sp.
3. Maxilla 1 palp with short conate terminal setae; peraeopod 7, merus slightly expanded, margins subparallel ..... *G. galatheae*
- Maxilla 1 palp with long conate terminal setae; peraeopod 7, merus expanded, posterior margin rounded ..... *G. latipes*

### *Galathella bassiana* n.sp.

Figs 4-6

**Type material.** HOLOTYPE, female, ovigerous (2 eggs), 3.2 mm, NMV J37595 and PARATYPE, female, AM P42287: 48 km ENE of Cape Tourville, Tasmania, Australia, 42°00.25'S 148°43.55'E, gravel with lumps of sandy mud aggregate, 1264 m, epibenthic sled, G.C.B. Poore, 30 October 1988, stn SLOPE 81. 1 PARATYPE, NMV J37596, south of Point Hicks, Victoria, Australia, 38°25.90'S 148°58.60'E to 38°26.60'S 148°57.10'E, muddy sandstone, 1850 m, epibenthic sled, G.C.B. Poore *et al.* on RV *Franklin*, 22 July 1986, Cruise CSIRO FR5/86, stn SLOPE 25. 2 PARATYPES, NMV J37597, south of Point Hicks, Victoria, Australia, 38°25.00'S 149°0.00'E, compacted clay, 1500 m, epibenthic sled, G.C.B. Poore *et al.* on RV *Franklin*, 22 July 1986, Cruise CSIRO FR5/86, stn SLOPE 27. 1 PARATYPE, NMV J37598, south of Point Hicks, Victoria, Australia, 38°21.90'S 149°20.00'E to 38°21.40'S 149°20.90'E, 1000 m, epibenthic sled, G.C.B. Poore *et al.* on RV *Franklin*, 23 July 1986, Cruise CSIRO FR5/86, stn SLOPE 32. 7 PARATYPES, NMV J37599, south of Point Hicks, Victoria, Australia, 38°19.60'S 149°24.30'E

to 38°19.00'S 149°27.30'E, rock, rubble, clay, sand, biogenic sediment, 930-951 m, epibenthic sled, M.F. Gomon *et al.* on RV *Franklin*, 23 July 1986, Cruise CSIRO FR5/86, stn SLOPE 33. 3 PARATYPES, NMV J37600, south of Point Hicks, Victoria, Australia, 38°16.40'S 149°27.60'E to 38°17.70'S 149°26.10'E, coarse shell, biogenic sediment, 800 m, epibenthic sled, M.F. Gomon *et al.* on RV *Franklin*, 23 July 1986, Cruise CSIRO FR5/86, stn SLOPE 34. 3 PARATYPES, AM P42290, off Freycinet Peninsula, Tasmania, Australia, 42°2.20'S 148°38.70'E, coarse shelly sand, 800 m, epibenthic sled, M.F. Gomon *et al.* on RV *Franklin*, 7 July 1986, Cruise CSIRO FR5/86, stn SLOPE 45. 1 PARATYPE, NMV J37601, 76 km south of Point Hicks, Victoria, Australia, 38°29.33'S 149°19.98'E, sandy mud, fine shell, 1840 m, epibenthic sled, G.C.B. Poore, 26 October 1988, stn SLOPE 69.

**Diagnosis.** Maxilla 1 palp with long, conate setae. Gnathopod 1 weakly subchelate. Telson moderately cleft.

**Description.** Based on holotype female, 3.2 mm; male not known. *Head and body:* without setae. *Head:* slightly longer than deep, ventrally truncated with straight

ventral margin, lateral cephalic lobe large, strongly projecting, apically rounded; rostrum absent; eyes apparently absent. *Antenna 1*: short,  $0.18 \times$  body; peduncular article 1 medium length, length  $1.5 \times$  breadth, with small midmedial swelling; peduncular article 2 short,  $0.21 \times$  article 1; peduncular article 3 short,  $0.13 \times$  article 1; accessory flagellum long,  $0.61 \times$  primary flagellum, 3-articulate, article 1 long,  $2.4 \times$  article 2; flagellum 6-articulate, with weak 2-field callynophore in female, with 1 bifurcate robust seta on each of flagellar articles 2–4, calceoli absent in female. *Antenna 2*: subequal in length to antenna 1; peduncle without brush setae, peduncular article 1 enlarged, not covering article 2, weakly geniculate between peduncular articles 3–4, article 3 long,  $0.75 \times$  article 4, peduncular articles 4 and 5 not enlarged in female, not known for male; flagellum 6-articulate, calceoli absent in female.

*Mouthpart bundle*: subquadrate. *Epistome* and *upper lip*: separate, epistome almost straight, upper lip slightly produced, apically rounded. *Mandible*: incisors symmetrical, large, with slightly convex margins; lacinia mobilis a long slender cuspidate peg; accessory setal row, left and right rows each with 3 short, slender, simple setae; intermediate setae absent; molar setose with reduced distal triturating surface; mandibular palp attached midway; article 1 short, length  $1.3 \times$  breadth; article 2 slender, length  $5.9 \times$  breadth,  $2.1 \times$  article 3, with 7 submarginal posterodistal A2-setae, without D2-setae; article 3 slender, blade-like, long, length  $3.9 \times$  breadth, with 1 proximal A3-seta, with 5 distal D3-setae and 3 apical E3-setae. *Maxilla 1*: inner plate narrow, with 2 pappose setae; outer plate extremely narrow with 10 setal-teeth in modified 7/4 crown

arrangement, ST1 to ST3 large, stout, weakly to multicuspidate, ST4–ST5 large, slender, 6-cuspidate, ST6 absent, left and right ST7 symmetrical, displaced down medial face, elongate, slender, multicuspidate medially, STA large, slender, 3-cuspidate, STB large, slender, 4-cuspidate, STC large, slender, 5-cuspidate, STD slender, 6-cuspidate; palp large, 2-articulate, with 3 long terminal robust setae, with 1 subterminal seta, robust flag seta present on distolateral corner, distomedial margin serrate. *Maxilla 2*: inner plate narrow, outer plate broader, inner plate length  $0.61 \times$  outer plate. *Maxilliped*: inner plate large, subrectangular, with 3 apical nodular setae, oblique setal row strong with 11 pappose setae; outer plate small, subovate, with 1 apical pappose seta, with 1 apical robust seta, medial setae small, blunt, submarginal setae long, simple; palp large, 4-articulate, article 2 slender, length  $2.7 \times$  breadth,  $1.4 \times$  article 3, article 3 long, slender, length  $2.6 \times$  breadth, dactylus well-developed, with 2 subterminal setae, unguis present.

*Gnathopod 1*: subchelate; coxa large, slightly shorter than coxa 2, tapering distally, anterior margin straight, posterior margin distally angled towards anterior margin; basis long, slender, length  $4.6 \times$  breadth, anterior margin smooth, with simple setae; ischium long, length  $2.1 \times$  breadth; merus, posterior margin with patch of short setae and a few simple setae; carpus subrectangular, very long, length  $4 \times$  breadth, longer than ( $1.4 \times$ ) propodus, with patch of very fine setae near posterior margin and long simple setae along posterior margin; propodus large, subrectangular, length  $3.1 \times$  breadth, margins subparallel, posterior margin smooth, straight, with simple, slender setae, palm extremely acute, margin straight, smooth, posterodistal corner with 1 medial and

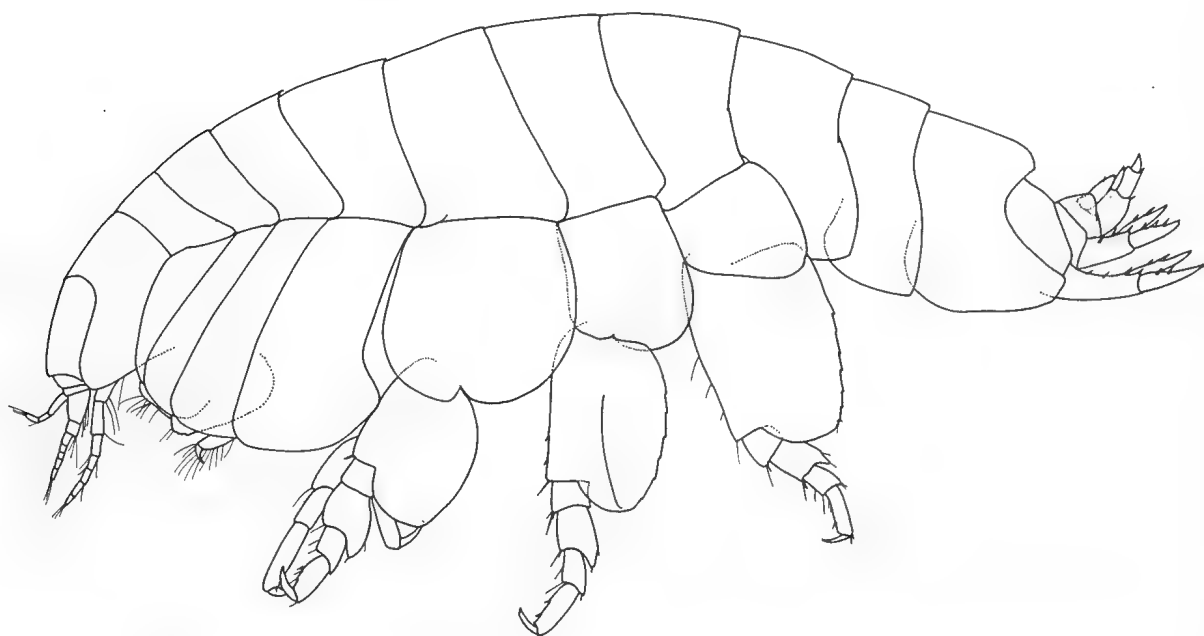


Fig. 4. *Galathea bassiana* n.sp., holotype female, 3.2 mm, NMV J37595, continental slope off Bass Strait, Victoria, Australia.



1 lateral robust setae; dactylus complex, with large subterminal spine and row of about 30 medial conate setae near anterior margin.

*Gnathopod 2*: minutely subchelate; coxa large, subequal in size to coxa 3; ischium long, length  $3 \times$  breadth; carpus long, length  $3.7 \times$  breadth, posterior margin straight; propodus subrectangular, long, length  $2 \times$  breadth, palm transverse, with concave, serrate margin, posterodistal corner with 1 medial robust seta; dactylus reaching corner of palm, posterior margin serrate.

*Peraeopod 3*: coxa large; merus weakly expanded anteriorly; merus-carpus without plumose setae in female; propodus with 3 robust setae along posterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 4*: coxa deeper than wide, with weak posteroventral lobe, anterior margin slightly rounded,

posterior margin slightly sloping anteriorly; merus weakly expanded anteriorly; merus-carpus without plumose setae in female; propodus with 2 robust setae along posterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 5*: coxa equilobate; basis expanded with posterior margin minutely crenate; merus expanded with rounded posterior margin; propodus with 3 robust setae along anterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 6*: coxa small, slightly lobate posteriorly; basis expanded posteriorly with minutely crenate posterior margin; merus expanded with rounded posterior margin; propodus with 4 robust setae along anterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 7*: basis expanded posteriorly, posterior margin almost straight, minutely crenate, posteroventral corner rounded, posteroventral margin rounded; merus slightly expanded posterodistally

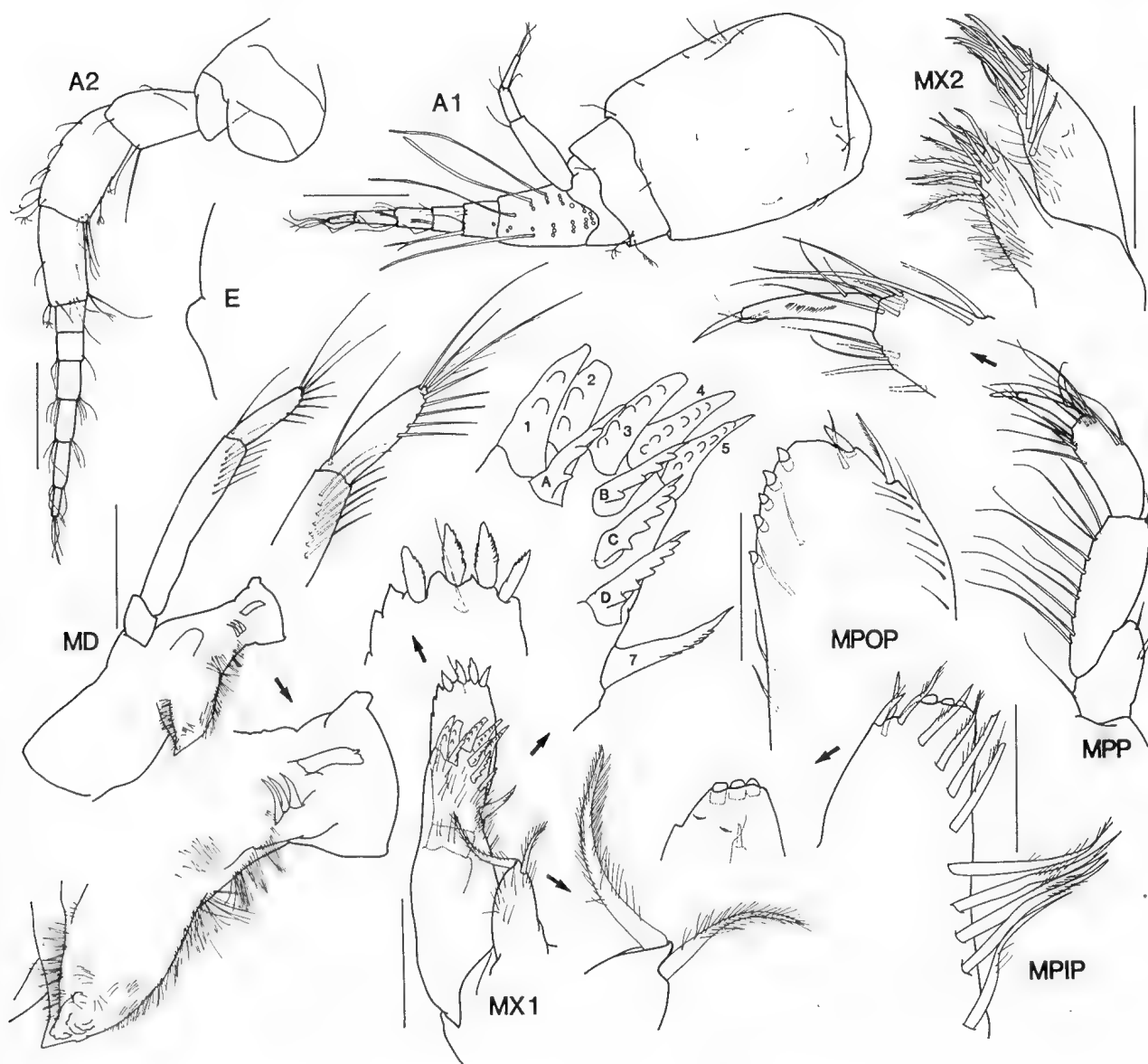


Fig. 5. *Galatella bassiana* n.sp., holotype female, 3.2 mm, NMV J37595, continental slope off Bass Strait, Victoria, Australia. Scales for MPOP, MPIP represent 0.05 mm, remainder represent 0.1 mm.

with 2 robust setae; propodus with 3 robust setae along anterior margin, with 2 distal locking setae, without setae along posterior margin; dactylus short, slender.

*Oostegites*: from gnathopod 2 to pereopod 5. *Gills*: from gnathopod 2 to pereopod 7, not pleated.

*Pleonites 1 to 3*: pleonite 3 truncated dorsodistally.

*Epimeron 1*: anteroventral corner broadly rounded.

*Epimeron 3*: posteroventral corner produced, narrowly rounded.

*Urosomites*: dorsally smooth; urosomite 3 without small dorsolateral seta. *Uropod 1*: without fine setae; peduncle with 3 dorsolateral, 1 apicolateral, 2

dorsomedial and 1 apicomедial robust setae; outer ramus slightly longer than inner ramus; outer ramus with 2 dorsal robust setae, inner ramus with 2 dorsal robust setae. *Uropod 2*: without fine setae; peduncle with 2 dorsolateral, 1 apicolateral and 1 apicomедial robust setae; outer ramus slightly longer than inner ramus; outer ramus with 3 dorsal robust setae, inner ramus with 2 dorsal robust setae; inner ramus without constriction. *Uropod 3*: peduncle short, length  $1.75 \times$  breadth, without dorsolateral flange, with 1 apicolateral and 1 apicomедial robust setae, without midlateral slender or

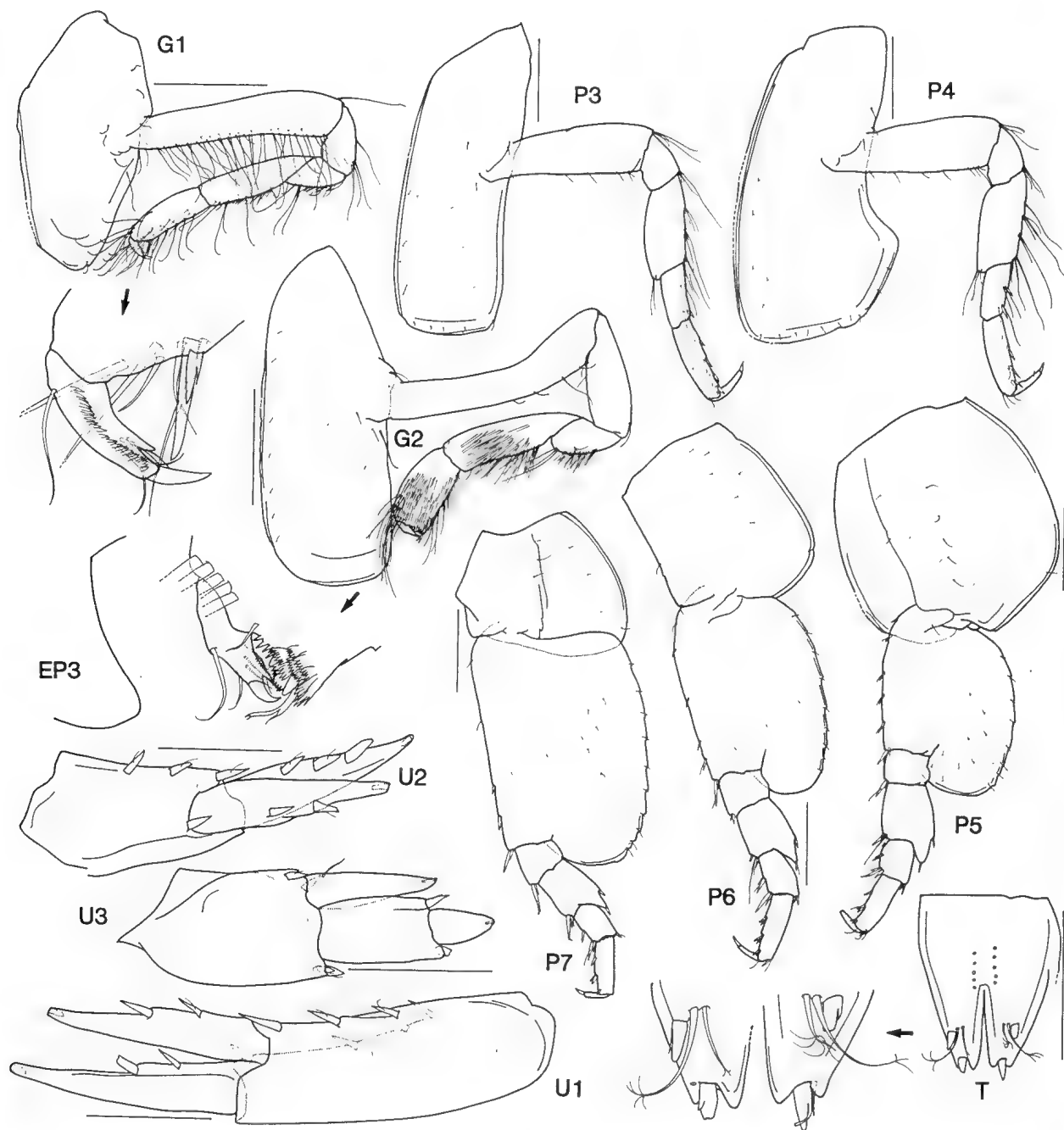


Fig. 6. *Galathea bassiana* n.sp., holotype female, 3.2 mm, NMV J37595, continental slope off Bass Strait, Victoria, Australia. Scales represent 0.1 mm.

robust setae, with 2 distoventral robust setae, with 1 simple seta; rami lanceolate, inner ramus shorter than (about 0.68 ×) outer ramus; outer ramus 2-articulate, article 2 short, article 1 with 1 lateral and 1 medial robust setae; inner ramus without robust setae; slender plumose setae absent in female. *Telson*: longer than broad, length 1.2 × breadth, moderately cleft (44%), with 1 dorsal robust seta on each lobe, without dorsal slender setae, distal margins incised, with 1 marginal penicillate seta on each lobe, without marginal simple setae, with 1 marginal robust seta on each lobe.

**Etymology.** Name refers to Bass Strait, between Victoria and Tasmania.

**Remarks.** *Galathella bassiana* differs from *G. palana* as follows: mandibular molar with very reduced distal triturating surface; gnathopod 1 subchelate, palm extremely acute with 2 posterodistal robust setae; and a moderately cleft telson. *Galathella bassiana* differs from *G. galathea* and *G. latipes* mainly in the moderately cleft telson.

*Galathella bassiana* and *G. palana* occur in the same geographic area, but they are separated by depth. *Galathella bassiana* occurs in 800 to 1850 m depth and *G. palana* occurs in 600 to 1000 m depth.

**Distribution.** *Galathella bassiana* occurs on the continental slope off south-eastern Australia in 800 to 1850 m depth.

### *Galathella palana* n.sp.

Figs 7–9

**Type material.** HOLOTYPE, female, ovigerous (3 eggs), 4.6 mm, NMV J14771 and PARATYPE, female, 4.0 mm, AM P42288: off Freycinet Peninsula, Tasmania, Australia, 42°2.20'S 148°38.70'E, coarse shelly sand, 800 m, epibenthic sled, M.F. Gomon *et al.* on RV *Franklin*, 7 July 1986, Cruise CSIRO FR5/86, stn SLOPE 45. 4 PARATYPES, NMV J37602, south of Point Hicks, Victoria, Australia, 38°16.40'S 149°27.60'E to 38°17.70'S 149°26.10'E, coarse shell, biogenic sediment, 800 m, epibenthic sled, M.F. Gomon *et al.* on RV *Franklin*, 23 July 1986, Cruise CSIRO FR5/86, stn SLOPE 34. 3 PARATYPES, NMV J14613, south of Point Hicks, Victoria, Australia, 38°19.10'S 149°14.30'E, coarse sand, 600 m, epibenthic sled, M.F. Gomon *et al.* on RV *Franklin*, 24 July 1986, Cruise CSIRO FR5/86, stn SLOPE 39. 5 PARATYPES, NMV J37603 and 5 PARATYPES, AM P42291: off Freycinet Peninsula, Tasmania, Australia, 42°0.20'S 148°37.70'E, coarse shelly sand, 720 m, epibenthic sled, M.F. Gomon *et al.* on RV *Franklin*, 27 July 1986, Cruise CSIRO FR5/86, stn SLOPE 46. 2 PARATYPES, NMV J37604, 54 km east-south-east of Nowra, New South Wales, Australia, 34°52.72'S 151°15.05'E, mud, fine sand, fine shell, 996 m, epibenthic sled, G.C.B. Poore *et al.*, 22 October 1988, stn SLOPE 53.

**Diagnosis.** Maxilla 1 palp with long, conate setae. Gnathopod 1 simple. Telson deeply cleft.

**Description.** Based on holotype female, 4.6 mm; paratype male, 4.0 mm. *Head and body*: without setae. *Head*: slightly longer than deep, ventrally truncated with straight ventral margin, lateral cephalic lobe large, broad, strongly projecting, apically rounded; rostrum small; eyes apparently absent. *Antenna 1*: peduncular article 1 medium length, length 1.5 × breadth, with small midmedial swelling; peduncular article 2 short, about 0.2 × article 1; peduncular article 3 short, 0.1 × article 1; accessory flagellum long, 0.53 × primary flagellum, 3-articulate, article 1 long, 1.2 × article 2; flagellum 7-articulate (male 9), with weak 2-field callynophore in female (strong 2-field callynophore in male), without flagellar robust setae, calceoli absent in female (5 present in adult male). *Antenna 2*: slightly longer than antenna 1; peduncle without brush setae (weak brush setae in male), strongly geniculate between peduncular articles 3–4, article 3 long, 1 × article 4 (male strongly geniculate between peduncular articles 3–4, article 3 long, 1 × article 4) peduncular articles 4 and 5 not enlarged in female or male; flagellum 8-articulate (male 14), calceoli absent in female (about 12 present in adult male).

*Mouthpart bundle*: subquadrate. *Epistome and upper lip*: separate, epistome straight, upper lip produced, apically rounded. *Mandible*: incisors symmetrical, large, with slightly convex margins; lacinia mobilis a long slender cuspidate peg; accessory setal row, left and right rows each with 3 short, slender, simple setae; intermediate setae absent; molar setose with reduced distal triturating surface; mandibular palp attached distally; article 1 short, length 1.2 × breadth; article 2 slender, length 5 × breadth, 1.9 × article 3, with 8 submarginal posterodistal A2-setae (male 9), without D2-setae; article 3 slender, blade-like, long, length 3.4 × breadth, with 1 proximal A3-seta (male 1), with 8 distal D3-setae (male 11) and 2 apical E3-setae. *Maxilla 1*: inner plate narrow, with 2 pappose setae; outer plate extremely narrow with 11 setal-teeth in 7/4 crown arrangement, ST1 to ST3 large, stout, weakly to multicuspitate, ST4 large, slender, 6-cuspidate, ST5 large, slender, 7-cuspidate, ST6 large, slender, 7-cuspidate, left and right ST7 symmetrical, displaced down medial face, elongate, slender, multicuspitate medially, STA large, slender, displaced from STB, 3-cuspidate, STB large, broad, 6-cuspidate, STC large, broad, multicuspitate, STD broad, multicuspitate; palp large, 2-articulate, with 3 long terminal robust setae, with 1 subterminal seta, robust flag seta present on distolateral corner, distomedial margin serrate. *Maxilla 2*: inner plate narrow, outer plate broader, inner plate length 0.52 × outer plate. *Maxilliped*: inner plate large, subrectangular, with 3 apical nodular setae, oblique setal row strong with 10 pappose setae; outer plate small, subovate, with many fine apical setae, with 2 apical robust setae, medial setae small, blunt, submarginal setae long, simple; palp large, 4-articulate, article 2 slender, length 3.1 × breadth, 1.5 × article 3, article 3 long, slender, length 2.7 × breadth, dactylus well-developed, with 3 subterminal setae, unguis present. *Gnathopod 1*: simple; coxa large, slightly shorter than

coxa 2, tapering distally, anterior margin slightly concave, anteroventral corner rounded, posterior margin distally angled towards anterior margin; basis long, slender, length  $5 \times$  breadth, anterior margin smooth, with simple setae; ischium long, length  $1.8 \times$  breadth; merus, posterior margin with a few simple setae; carpus subrectangular, very long, length  $5.1 \times$  breadth, longer than  $(1.7 \times)$  propodus, with patch of very fine setae near posterior margin and long simple setae along posterior margin; propodus large, subrectangular, length  $2.8 \times$  breadth, tapering distally, posterior margin smooth, straight, with 1 simple robust seta and simple, slender setae, palm absent; dactylus simple, with subterminal spine. *Gnathopod 2*: minutely subchelate; coxa large, subequal in size to coxa 3; ischium long, length  $2.9 \times$  breadth; carpus long, length  $3.2 \times$  breadth, posterior margin broadly lobate; propodus subrectangular, long, length  $2 \times$  breadth, palm transverse, with straight, serrate margin, posterodistal corner with 1 medial robust seta; dactylus reaching corner of palm, posterior margin smooth.

*Peraeopod 3*: coxa large; merus weakly expanded anteriorly; merus-carpus without plumose setae in male and female; propodus with 2 robust setae along posterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 4*: coxa deeper than wide, with weak posteroventral lobe, anterior margin slightly rounded, posterior margin slightly sloping anteriorly; merus weakly expanded anteriorly; merus-carpus without plumose setae in male and female; propodus with 3 robust setae along posterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 5*: coxa equilobate; basis expanded with posterior margin minutely crenate; merus expanded with rounded posterior margin; propodus with

2 robust setae along anterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 6*: coxa small, slightly lobate posteriorly; basis expanded posteriorly with minutely crenate posterior margin; merus expanded with rounded posterior margin; propodus with 3 robust setae along anterior margin, with 2 distal locking setae; dactylus short, stocky. *Peraeopod 7*: basis expanded posteriorly, posterior margin slightly rounded, minutely crenate, posteroventral corner rounded, posteroventral margin rounded; merus slightly expanded posterodistally with 3 robust setae; propodus malformed on holotype, paratype with 4 robust setae on anterior margin, with 2 distal locking setae, without setae along posterior margin; dactylus short, stocky.

*Oostegites*: from gnathopod 2 to peraeopod 5. *Gills*: from gnathopod 2 to peraeopod 7, not pleated.

*Pleonites 1 to 3*: pleonite 3 truncated dorsodistally. *Epimeron 1*: anteroventral corner broadly rounded. *Epimeron 3*: posteroventral corner produced, narrowly rounded. *Urosomites*: dorsally smooth; urosomite 3 with 1 small dorsolateral seta. *Uropod 1*: without fine setae; peduncle with 5 dorsolateral, 1 apicolateral, 3 dorsomedial and 2 apicomedial robust setae; outer ramus slightly shorter than inner ramus; outer ramus with 2 dorsal robust setae, inner ramus with 2 dorsal robust setae. *Uropod 2*: without fine setae; peduncle with 3 dorsolateral, 1 apicolateral, 1 dorsomedial and 1 apicomedial robust setae; outer ramus slightly shorter than inner ramus; outer ramus with 3 lateral robust setae; inner ramus with 2 lateral and 1 medial robust setae; inner ramus without constriction. *Uropod 3*: peduncle short, length  $1.6 \times$  breadth, without dorsolateral flange, with 1 apicolateral and 2 apicomedial robust setae, without midlateral slender

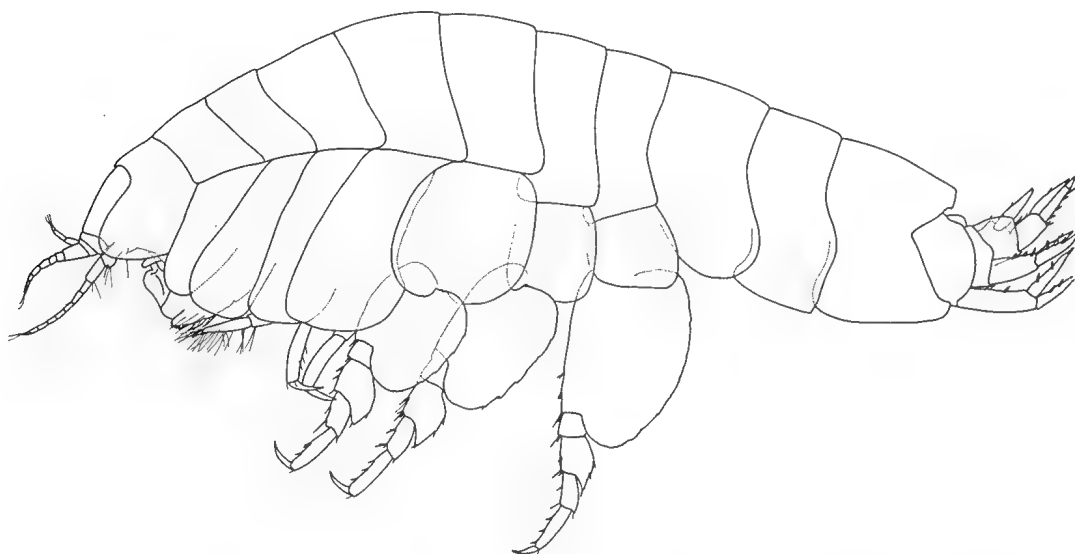


Fig. 7. *Galathella palana* n.sp., paratype female, 4.0 mm, AM P42288, continental slope off Bass Strait, Victoria, Australia.

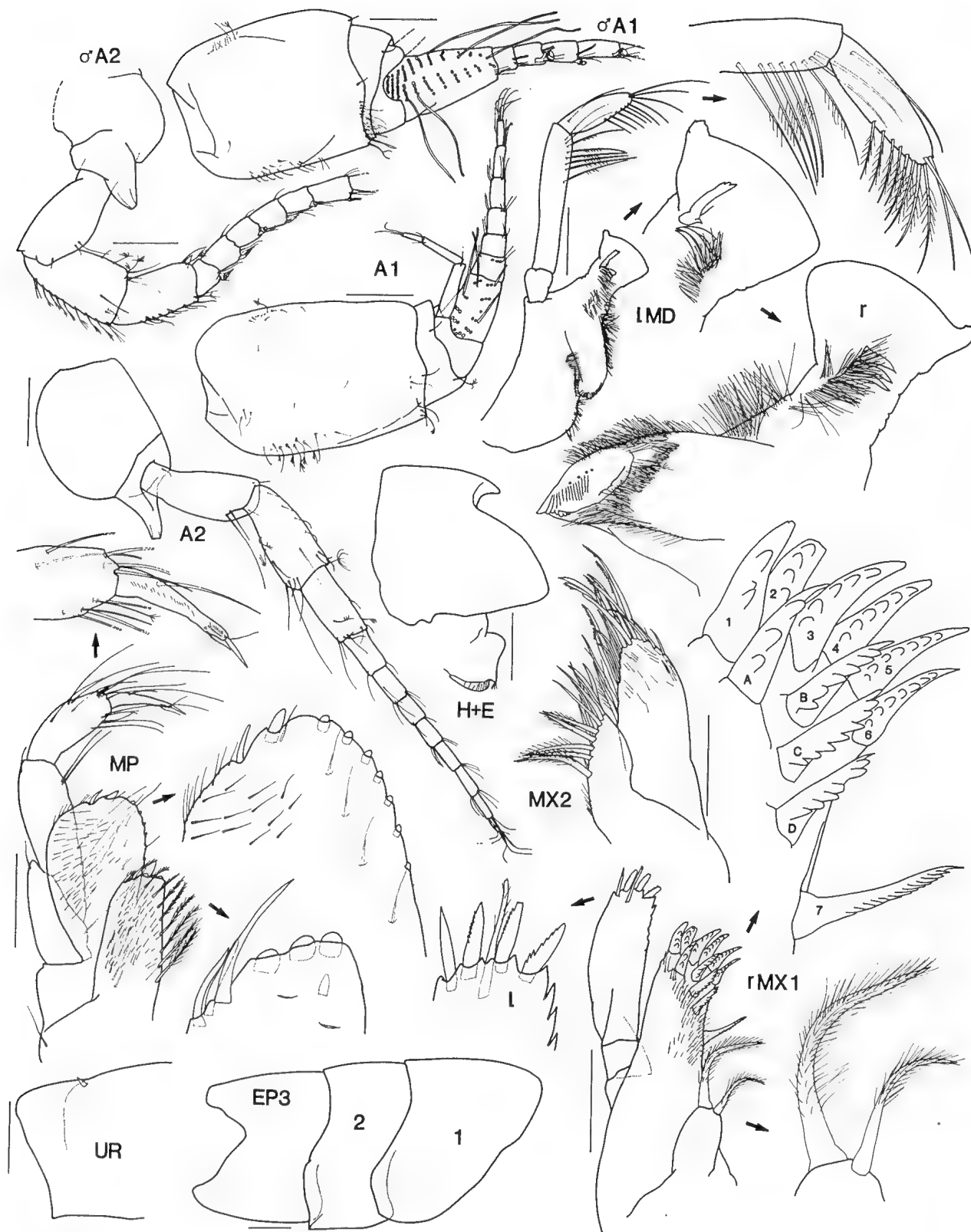


Fig. 8. *Galathella palana* n.sp., holotype female, 4.6 mm, NMV J14771; paratype male, 4.0 mm, NMV J14613; continental slope off Bass Strait, Victoria, Australia. Scale for UR represents 0.2 mm, remainder represent 0.1 mm.

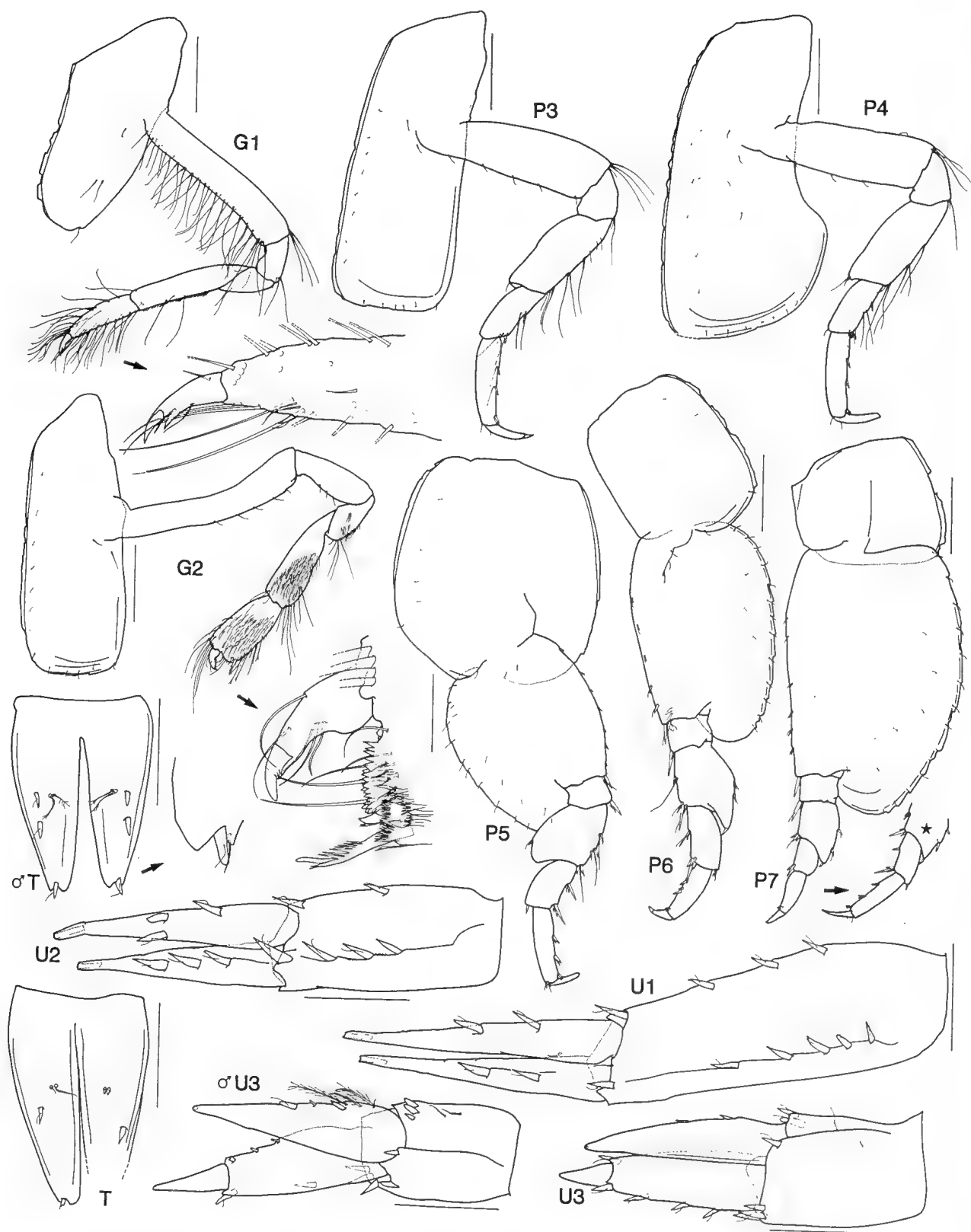


Fig. 9. *Galathella palana* n.sp., holotype female, 4.6 mm, NMV J14771; ★ paratype female, 4.0 mm, NMV J37602 (distal articles of holotype P7 are re-growth); continental slope off Bass Strait, Victoria, Australia. Scales for U1–3, T represent 0.1 mm, remainder represent 0.2 mm.

or robust setae, with 3 distoventral robust setae, with 2 simple setae; rami lanceolate, inner ramus shorter than (about 0.88×) outer ramus; outer ramus 2-articulate, article 2 short, article 1 with 4 lateral and 1 medial robust setae (male with 1 lateral, 3 medial); inner ramus with 2 lateral robust setae (male with 3 lateral); slender plumose setae absent in female (present in male). *Telson*: longer than broad, length 1.5 × breadth, deeply cleft (87%), with 1 dorsal robust seta on each lobe, without dorsal slender setae, distal margins incised, with 1 marginal penicillate seta on each lobe, without marginal simple setae, with 1 marginal robust seta on each lobe.

**Etymology.** Named for the village of Palana on Flinders Island, Bass Strait.

**Remarks.** *Galathella palana* differs from other species in the genus in having a simple gnathopod 1. In addition it differs from *G. bassiana* in having a deeply cleft telson.

**Distribution.** *Galathella palana* occurs on the continental slope off south-eastern Australia in 600 to 1000 m depth.

### *Gippsia* n.gen.

**Diagnosis.** *Head*: lateral cephalic lobe large, broad, subacute. *Antenna 1*: peduncular article 1 without posterodistal tooth; callynophore well-developed in female and male, without posterodistal simple or robust setae. Upper lip/epistome fused. *Mandible*: molar setose, with reduced distal triturating surface; mandibular palp without proximal A3-setae, with slender, blade-like article 3. *Maxilla 2*: outer plate shorter than inner plate, with extremely elongate setae. *Maxilliped*: outer plate distomedially rounded. *Gnathopod 1* simple; coxa about as long as coxa 2, not tapering distally; ischium and carpus short. [Peraeopods 3 and 4: males, plumose setae on posterior margin of merus and carpus not known]. Epimeron 3: posteroventrally produced. Telson entire.

**Type species.** *Gippsia jonesae* n.sp.

**Species composition.** *Gippsia* contains *G. jonesae* n.sp.

**Etymology.** Named for the Gippsland area of Victoria.

**Remarks.** *Gippsia* appears to be most closely related to *Ichnopus*. The main differences are: in *Gippsia* the molar has a reduced triturating surface; the outer plate of maxilla 2 is shorter than the inner plate; the ischium of gnathopod 1 is short; and the telson is entire.

### *Gippsia jonesae* n.sp.

Figs 10, 11

**Type material.** HOLOTYPE, female, 3.0 mm (ovigerous, 1 egg), NMV J22344 and PARATYPE, female, NMV J22345: 15.3 km east-south-east of eastern edge of Lake Tyers, Victoria, Australia, 37°53.39'S 148°15.40'E, Smith-McIntyre grab, coarse sand, 43 m, N. Coleman, 4 June 1991, stn MSL-EG 70. PARATYPE, male, 2.0 mm, NMV J22346, 15.5 km south-east of Point Ricardo, Victoria, Australia, 37°53.14'S 148°28.94'E, Smith-McIntyre grab, medium sand, 45 m, N. Coleman, 4 June 1991, stn MSL-EG 81. PARATYPE, NMV J26744, 7.3 km south-south-west of Cape Conran, Eastern Bass Strait, Victoria, Australia, 37°52.65'S 148°42.15'E, Smith-McIntyre grab, coarse sand, 49 m, N. Coleman, February 1991, stn MSL-EG 117. PARATYPES, 1 female, 3.0 mm, 1 male, AM P42289, 15.3 km east-south-east of eastern edge of Lake Tyler, Eastern Bass Strait, Victoria, Australia, 37°53.39'S 148°15.40'E, Smith-McIntyre grab, coarse sand, 43 m, N. Coleman, February 1991, stn MSL-EG 97. PARATYPE, NMV J26747, 15.3 km east-south-east of eastern edge of Lake Tyler, Eastern Bass Strait, Victoria, Australia, 37°53.39'S 148°15.40'E, Smith-McIntyre grab, coarse sand, 43 m, N. Coleman, February 1991, stn MSL-EG 98.

**Description.** Holotype female, 3.0 mm, paratype male, 2.0 mm. *Head and body*: without setae. *Head*: deeper than long, lateral cephalic lobe large, broad, subacute; rostrum absent; eyes indistinct, irregularly reniform, colour unknown, not enlarged in adult male. *Antenna 1*: medium length; peduncular article 1 short, length 1.1 × breadth; peduncular article 2 short, 0.34 × article 1; peduncular article 3 short, 0.05 × article 1; accessory flagellum long, 0.51 × primary flagellum, 3-articulate, article 1 long, 1.2 × article 2 (male long, 2.1 × article 2), not forming cap; flagellum 7-articulate (male 6), with strong 1-field callynophore in female (strong 2-field callynophore in male), without flagellar robust setae, calceoli absent in female and male. *Antenna 2*: subequal in length to antenna 1 in female and male; peduncle without brush setae in female and male, weakly geniculate between peduncular articles 3–4, article 3 short, 0.48 × article 4 (male weakly geniculate between peduncular articles 3–4, article 3 short, 0.25 × article 4), peduncular articles 4 and 5 not enlarged in female or male; flagellum 6-articulate (male 5), calceoli absent in female and male.

*Mouthpart bundle*: subquadrate. *Epistome* and *upper lip*: fused, bilobate. *Mandible*: incisors symmetrical, large, with slightly convex margins; lacinia mobilis a cuspidate peg; accessory setal row, left row with 3, right row with 4 short, slender, serrate setae; intermediate setae absent; molar setose with rudimentary distal triturating surface; mandibular palp attached distally; article 1 short, length 1 × breadth; article 2 slender, length 4.3 × breadth, 1.6 × article 3, with 3 distal A2-setae (male 3), without D2-setae; article 3 slender, blade-like, long, length 3.1 × breadth, without A3-setae, with 1 distal D3-seta (male 1) and 3 apical E3-setae. *Maxilla 1*: inner plate narrow, with 2 pappose setae; outer plate



extremely narrow with 11 setal-teeth in 7/4 crown arrangement, ST1 to ST3 large, slender, multicuspitate, ST4 large, slender, 8-cuspidate, ST5 large, slender, 9-cuspidate, ST6 large, slender, 14-cuspidate, ST7 displaced down medial face, large, slender, 27-cuspidate medially, STA large, slender, displaced from STB,

multicuspidate, STB long, slender, 7-cuspidate, STC long, slender, 6-cuspidate, STD long, slender, 6-cuspidate; palp large, 2-articulate, with 3 short terminal conate setae, with 1 subterminal seta, robust flag seta present on distolateral corner, distomedial margin serrate. *Maxilla 2*: inner plate narrow, outer plate broader,

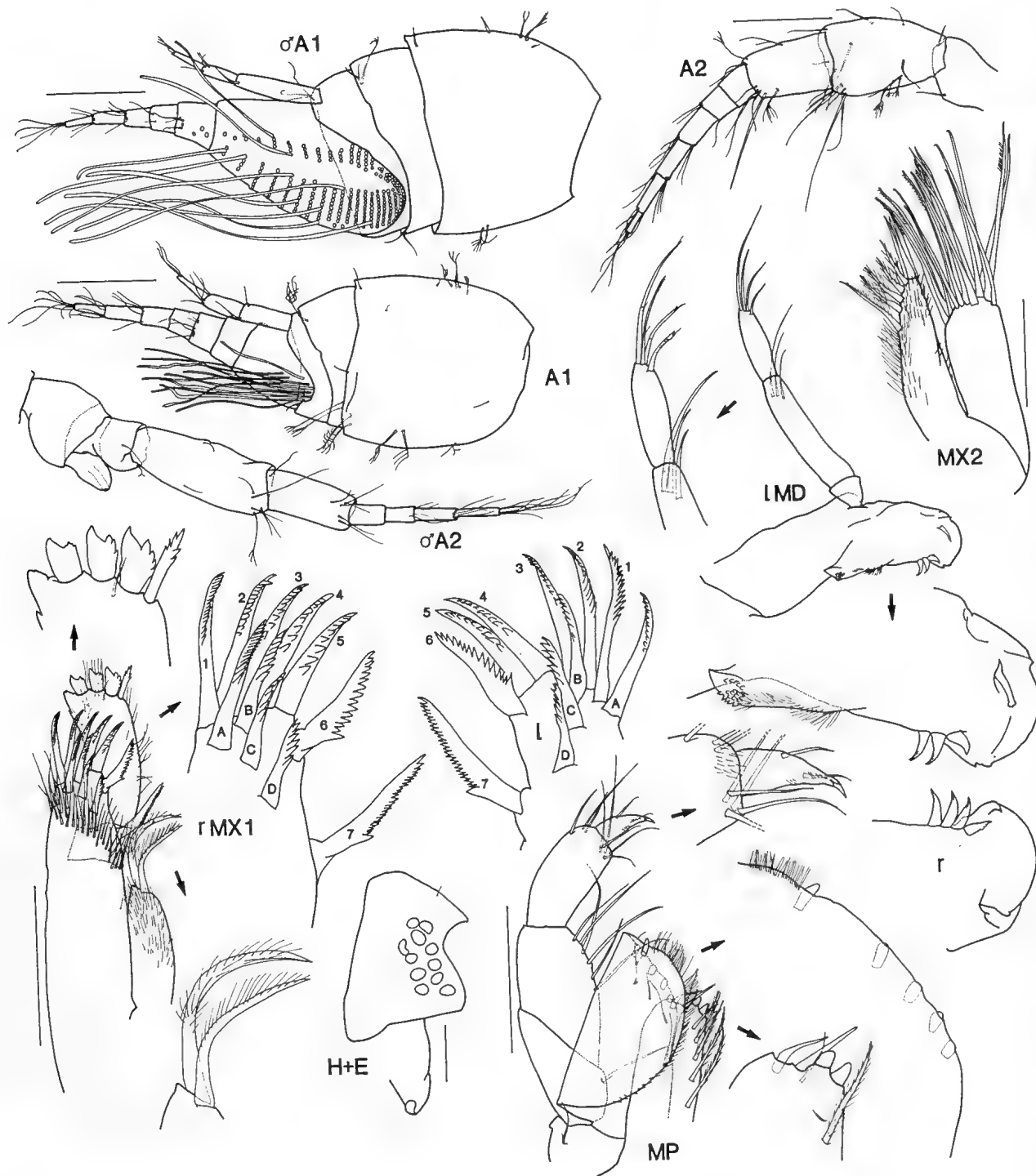


Fig. 10. *Gippisia jonesae* n.gen., n.sp., holotype female, 3.0 mm, NMV J22344; paratype male, 2.0 mm, NMV J22346; off Gippsland, Victoria, Australia. Scale for H+E represents 0.2 mm, remainder represent 0.1 mm.

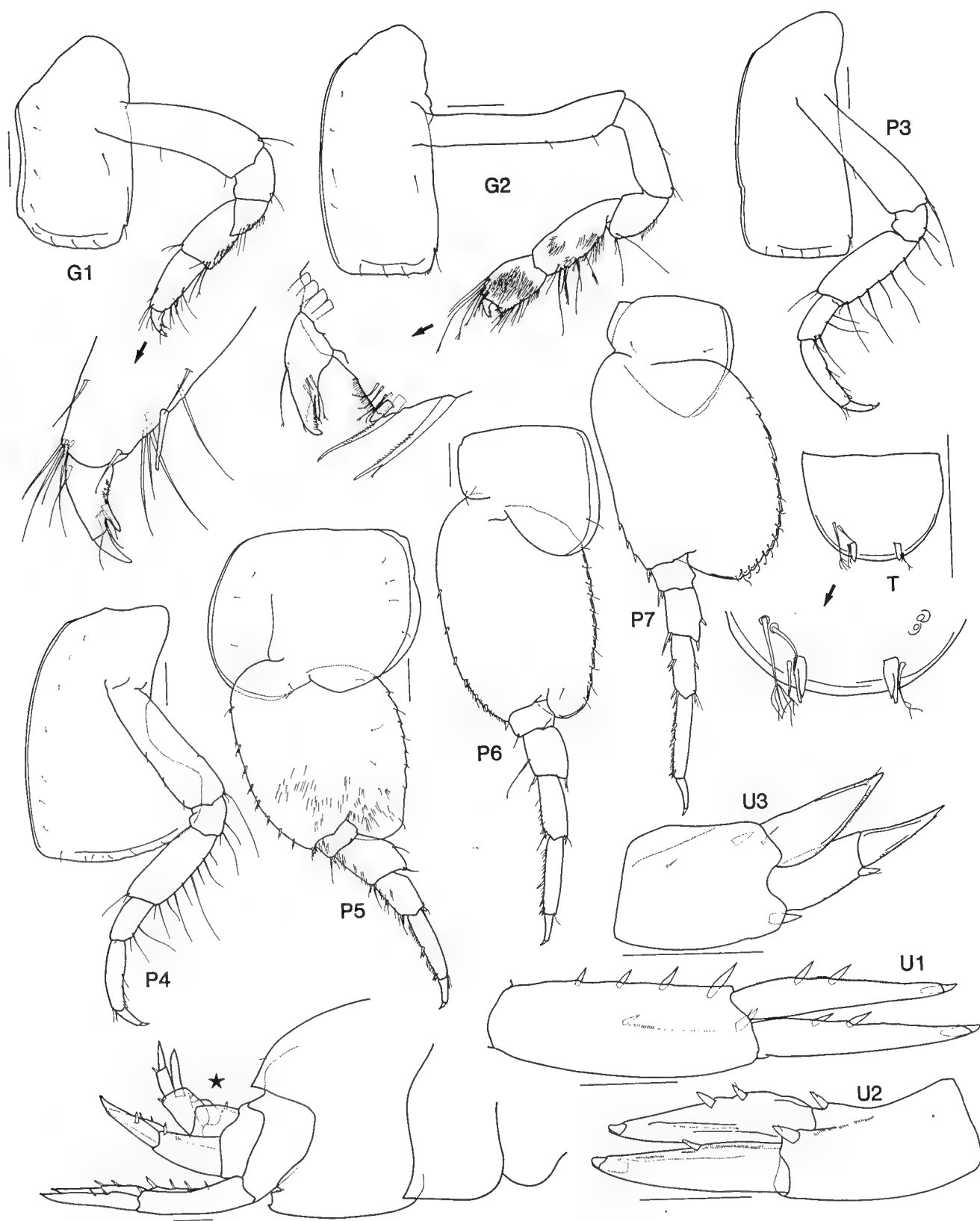


Fig. 11. *Gippisia jonesae* n.gen., n.sp., holotype female, 3.0 mm, NMV J22344; ★ paratype female, 3.0 mm, AM P42289; off Gippsland, Victoria, Australia. Scales represent 0.1 mm.

inner plate length  $1.3 \times$  outer plate, outer plate with extremely elongate slender setae. *Maxilliped*: inner plate large, subrectangular, with 2 apical nodular setae, oblique setal row strong with 5 pappose setae; outer plate medium size, subovate, without apical slender setae, with 1 apical robust seta, medial setae small, blunt, submarginal setae long, simple; palp large, 4-articulate, article 2 very broad, length  $1.8 \times$  breadth,  $1.2 \times$  article 3, article 3 long, broad, length  $2.2 \times$  breadth, dactylus well-developed, with 2 subterminal setae, unguis present.

*Gnathopod 1*: simple; coxa large, about as long as coxa 2, anterior margin slightly concave, anteroventral corner rounded, posterior margin straight; basis long, slender, length  $2.9 \times$  breadth, anterior margin smooth, with simple setae; ischium short, length  $1.4 \times$  breadth; merus, posterior margin with patch of short setae; carpus subrectangular, short, length  $1.9 \times$  breadth, longer than  $(1.1 \times)$  propodus, with patch of very fine setae near posterior margin; propodus large, subrectangular, length  $2.1 \times$  breadth, margins slightly converging distally, posterior margin smooth, straight, with 1 simple robust seta; dactylus simple, with subterminal spine. *Gnathopod 2*: minutely subchelate; coxa large, subequal in size to coxa 3; ischium long, length  $3 \times$  breadth; carpus long, length  $2.8 \times$  breadth, posterior margin straight; propodus subquadrate, short, length  $1.5 \times$  breadth, palm transverse, with straight, serrate margin, posterodistal corner with 1 (male 1) medial robust seta; dactylus reaching corner of palm, posterior margin smooth proximally with serrate tip.

*Peraeopod 3*: coxa large; merus weakly expanded anteriorly; merus-carpus without plumose setae in male and female; propodus with 2 slender setae along posterior margin, with 1 distal locking seta; dactylus short, slender. *Peraeopod 4*: coxa deeper than wide, with large posteroventral lobe, anterior margin slightly rounded, posterior margin slightly sloping anteriorly; merus weakly expanded anteriorly; merus-carpus without plumose setae in male and female; propodus with 2 slender setae along posterior margin, with 1 distal locking seta; dactylus short, slender. *Peraeopod 5*: coxa equilobate; basis expanded with posterior margin minutely crenate; merus expanded with rounded posterior margin; propodus with finely setose anterior margin, with 2 robust setae along anterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 6*: coxa small, slightly lobate posteriorly; basis expanded posteriorly with minutely crenate posterior margin; merus not expanded posteriorly; propodus with finely setose anterior margin, with 2 robust setae along anterior margin, with 2 distal locking setae; dactylus short, slender. *Peraeopod 7*: basis expanded posteriorly, posterior margin slightly rounded, crenate, posteroventral corner rounded, posteroventral margin rounded; merus not expanded posteriorly, with 2 robust setae; propodus with finely setose anterior margin, with 2 robust setae along anterior margin, 2 distal locking setae, without setae along posterior margin; dactylus short, slender.

*Oostegites*: from gnathopod 2 to peraeopod 5. *Gills*: from gnathopod 2 to peraeopod 6, not pleated.

*Pleonites 1 to 3* dorsally smooth. *Epimeron 1*: anteroventral corner rounded. *Epimeron 3*: posteroventral corner produced, with minute bicuspidate notch. *Urosomites*: dorsally smooth; urosomite 3 with small dorsolateral seta. *Uropod 1*: without fine setae; peduncle with 1 dorsolateral, 1 apicolateral, 3 dorsomedial and 1 apicomедial robust setae; rami subequal in length; outer ramus with 2 dorsal robust setae, inner ramus with 2 dorsal robust setae. *Uropod 2*: without fine setae; peduncle with 1 apicolateral and 1 apicomедial robust setae; rami subequal in length; outer ramus with 1 dorsal robust seta, inner ramus with 2 dorsal robust setae; inner ramus without constriction. *Uropod 3*: peduncle short, length  $1.4 \times$  breadth, without dorsolateral flange, with 1 apicomедial robust seta, without midlateral slender or robust setae, with 1 distoventral robust seta, without plumose setae in female or male; rami lanceolate, inner ramus shorter than  $(0.79 \times)$  outer ramus; outer ramus 2-articulate, article 2 long, article 1 with 1 lateral robust seta; inner ramus without robust setae; slender plumose setae absent in female and male. *Telson*: shorter than broad, length  $0.75 \times$  breadth, entire, without dorsal robust setae, without dorsal slender setae, distal margin rounded, with 2 marginal penicillate setae, without marginal simple setae, with 2 marginal robust setae.

**Etymology.** Named for Diana Jones, carcinologist at the Western Australian Museum, for her contribution to the systematics of Australian crabs and barnacles.

**Remarks.** For reasons put forward in the remarks under *Galathella* it is highly probable that *Gippsia jonesae* is a demersal scavenger and/or micropredator.

**Distribution.** *Gippsia jonesae* is known from off the central Victorian coast, Australia, in 40 to 50 m depth.

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## Marine Amphipoda of Micronesia: Kosrae

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**ABSTRACT.** Twenty-five species of marine amphipod are reported from Kosrae, Federated States of Micronesia. *Elasmopus aduncus* n.sp., *Paradexamine tafunsaka* n.sp., *Gammarella utwe* n.sp. and *Cerapus micronesicus* n.sp. are described.

MYERS, A.A., 1995. Marine Amphipoda of Micronesia: Kosrae. Records of the Australian Museum 47(1): 27-38.

A small collection of marine amphipods from Kosrae, Federated States of Micronesia was made available to me for study, by Dr Graham Edgar, University of Tasmania. The collection consisted of only four shallow-water samples, but these together produced 25 species of which four in the genera *Elasmopus*, *Paradexamine*, *Gammarella* and *Cerapus* were new to science. Nine families were recorded, the best represented were the Melitidae and Ampithoidae with 11 and 7 species each respectively. Descriptions of four new species are provided. Types are deposited in the collections of the Australian Museum, Sydney. All other material is currently in the collections of the writer, and will be donated to the Australian Museum on completion by the writer of the work in the region.

**Abbreviations used in figures.** Hd – Head, L – Labium, Mx1 – Maxilla 1, Md – Mandible, Mxp – Maxilliped, G1 – Gnathopod 1, G2 – Gnathopod 2, P3-7 – Pereopods 3-7, Ep 1-3 – Epimera 1-3, Us – Urosome, U1-3 – Uropods 1-3. T – Telson.

### *Elasmopus alalo* Myers

*Elasmopus alalo* Myers, 1986: 273, figs 4, 5.  
*Elasmopus pseudaffinis*.—Barnard, 1965: 501, figs 12-13.—Ledoyer, 1972: 219, pls 38,39.—Ledoyer, 1978 (in part): 273, fig. 29a.—Berents, 1983: 118; figs 15, 16.—Ledoyer, 1984: 65, fig. 30b (not *E. pseudaffinis* Schellenberg, 1938: 53, fig. 25).

**Remarks.** Myers (1986) noted the existence of two distinct species masquerading under the name *Elasmopus pseudaffinis* Schellenberg and established the name *E. alalo* Myers for the second species.

In the present material, adult males agree closely with those described from Tonga (Myers, 1986). In juvenile males, the palmar excavation on the male gnathopod 2 is weak or missing so that they resemble that appendage of *E. spinimanus* Walker, 1904. The possibility exists that *E. alalo* is in fact, the hyperadult form of *E. spinimanus*, from Sri Lanka, developing a deep palmar excavation in specimens over about 8.0 mm. The material figured by Ruffo (1969) from the Red Sea, under the name *E. steinitzi* (which does not appear to

be the same as the material figured in the original description by Ruffo, 1959) is also scarcely distinguishable from juvenile male *E. alalo*.

It would be premature to synonymise the above materials here, since topotypic material must be examined through its growth stages to ascertain the relationship of the species.

**Distribution.** Madagascar, Mauritius, north-eastern Australia, New Caledonia, Federated States of Micronesia, Kiribati, Marshall Islands, Tonga.

### *Elasmopus gracilis* Schellenberg

*Elasmopus gracilis* Schellenberg, 1938, 59, fig. 31.—Ledoyer, 1967: 129, fig. 11.—Ruffo, 1969: 29, fig. 8.—Ledoyer, 1982: 488, fig. 176.—Myers, 1986: 277, figs 6, 7.

*Elasmopus brasiliensis* Barnard, 1965: 500, fig. 11 (not *E. brasiliensis* [Dana, 1853]).

**Remarks.** *Elasmopus gracilis* has been recorded from the Gilbert Islands (Schellenberg, 1938), from Tonga (Myers, 1986), from Madagascar (Ledoyer, 1967, 1982) and from the Red Sea (Ruffo, 1969). It has also been recorded from Micronesia (Barnard, 1965) under the name *Elasmopus brasiliensis* (Dana, 1853). Material described by Ledoyer (1967, 1982), by Barnard (1965), by Myers (1986) and in the present material, all show a characteristic sub-palmar ridge on the male gnathopod 2. Schellenberg neither described nor figured the ridge, but the description and figures otherwise agree with the above material. Ruffo's (1969) material is unique in possessing a row of strong spines on the anterior margin of the male gnathopod 2 carpus. For the moment all the above material is treated as synonymous.

### *Elasmopus aduncus* n.sp.

Figs 1, 2

**Type material.** HOLOTYPE male, 4.2 mm, AM P42695, off Tafunsak village, Kosrae 5°22'N 163°02'E, rock washings from exposed reef flat, 16 July 1991, stn 4. PARATYPES (14) AM P42696 same data as holotype.

**Description.** Length to 4.2 mm. Pereon segments and pleon segments 1–2 with a few long dorsal setae. **Head:** with subocular notch, eye relatively large. **Antenna 1:** two-thirds body length, peduncular article 1 and 2 sub-equal in length, article 3 a little over half length of article 2, flagellum a little shorter than peduncle with about 18 articles, accessory flagellum composed of one long and one rudimentary article. **Antenna 2:** small, scarcely one-third length of antenna 1, peduncular article 4 longer than 5, flagellum shorter than combined length of articles 4+5 with four articles, the terminal article rudimentary. **Mandible:**

palp articles 2 and 3 subequal in length, article 3 weakly falcate. **Maxilla 1:** inner plate elongate with two long terminal pappose setae and numerous small fine setae. **Gnathopod 1:** coxa sub-quadrate with a few long distal setae, basis stout, carpus and propodus subequal in length, palm very oblique, dactylus fitting palm. **Male gnathopod 2:** basis stout, anterior margin with flange proximally protuberant, carrying about six large, curved spines along its mediodistal length, carpus short, cup-shaped, propodus enlarged, four times length of carpus, posterior margin convex, with small, sub-acute mediodistal tooth, palm short, weakly lobed, dactylus slender, curved, reaching along two-thirds of propodus posterior margin. **Female gnathopod 2:** basis slender, carpus more elongate, propodus less than two times length of carpus, palm very oblique, defined by a spine, dactylus fitting palm. **Pereopods 3–4:** typical for genus, propodus palm with spatulate spine. **Pereopods 5–7:** robust, basis posterior margin expanded, weakly to moderately convex, weakly crenulate. **Epimeron 1:** posteriorly rounded, lower margin with a single spine. **Epimera 2–3:** posterodistal margin scalloped, with small setae inserted between scallops, lower margin with two to three spines. **Uropod 1:** peduncle longer than rami, inner ramus longer than outer, peduncle and inner ramus with very long spines, outer ramus with a single spine. **Uropod 2:** peduncle short, inner ramus longer than outer, outer ramus lacking marginal spines. **Uropod 3:** peduncle short, inner ramus slender, about half length of outer ramus. **Telson:** apices excavate, each bearing one long and one short spine.

**Remarks.** *Elasmopus aduncus* appears to be closest to *E. hooheno* Barnard, 1970, which occurs in the same samples. *Elasmopus aduncus* differs from *E. hooheno* in the presence of a row of hooked spines on the basis of the male gnathopod 2, in the proximal expansion on the outer face of the anterior margin of that podomere, and in the configuration of processes on the propodus of that appendage. In addition, the inner ramus of uropod 3 is much shorter and more slender in *E. aduncus* than it is in *E. hooheno*. Diagnostic characteristics in combination are the short antenna 2, spinous basis and weakly toothed and weakly setiferous propodus of the male gnathopod 2, weakly toothed, non-castellate basis of pereopods 5–7 and scalloped posterior margins of epimera 1–3. *Elasmopus menurte* Barnard has similar pereopods 5–7 but differs in most other respects. The spatulate spine on the propodus of pereopods 3–4 is also found in *E. diplonyx* Schellenberg, 1938 and *E. atolgidus* Barnard, 1965. Both species are poorly known. *Elasmopus diplonyx*, as described by Barnard (1970), differs in lacking scalloped epimera and in having castellate pereopod 6–7 basis. Schellenberg's description is brief, but no mention is made of a spinose basis of the male gnathopod 2. *Elasmopus atolgidus*, known only from a female, appears to differ in the rounded telsonic apices, larger inner ramus of uropod 3 and non-scalloped epimera.



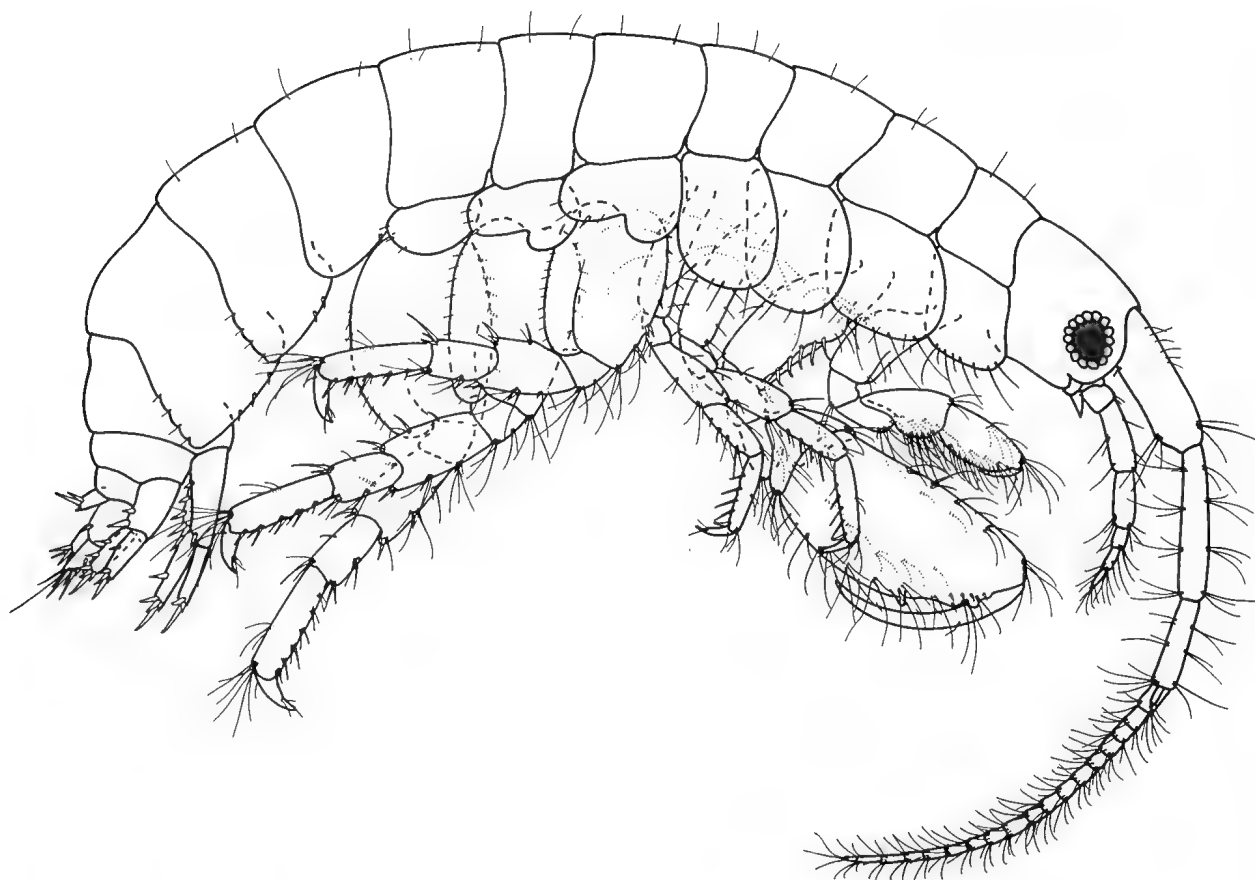


Fig. 1. *Elasmopus aduncus* n.sp. male, 4.2 mm; off Tafunsak Village, Kosrae.

**Etymology.** From the Latin *aduncus* meaning bent in, referring to the strong bent spines on the basis of the male gnathopod 2.

*Melita celericula* Croker

*Melita celericula* Croker, 1971: 100, figs 1, 2.

**Remarks.** Croker (1971) described this species from the Micronesian atolls of Enewetak, Majuro and Kwajalein where it was common. This species was one of the commoner amphipods in the present Kosrae collections.

*Paradexamine tafunsaka* n.sp.

Figs 3, 4

?*Paradexamine windarra* Ledoyer, 1984, p. 54, fig. 25; not *P. windarra* Barnard, 1972, 138, figs 78–80.

**Type material:** HOLOTYPE female, 2.7 mm, AM P42697, Tafunsak Village (5°22'N 163°02'E), rope-fibre tied to coral,

5 m depth, 28 October 1990, stn 3. PARATYPE female, AM P42805 same data as holotype.

**Description.** Length 2.7 mm. **Head:** with eye lobes rounded. **Antenna 1:** articles in the basodistal ratios 3:4:2, article 2 lower margin with discontinuity, a broad basal region delimited from a narrower distal region by a pair of stout, unequal spines, flagellum longer than peduncle with 14 articles. **Antenna 2:** only a little shorter than antenna 1, peduncle article 4 a little shorter than article 5, flagellum with four articles. **Mandible:** molar heavily tritulative, lacinia mobilis bifurcate. **Maxilla 1:** inner plate large, asetiferous, palp slender, reaching only 75% along outer plate and with two long terminal simple setae. **Maxilla 2:** inner plate short, little more than half length of outer plate and with three terminal setae. **Labium:** outer plate anterior margin with two sharp teeth. **Maxilliped:** inner plate tiny, tipped with one seta, outer plate broadly rounded, palp article 4 not reaching apex of outer plate. **Coxae 1–3:** narrowing a little distally, coxa 4 disproportionately larger than the preceding coxae, its posterior margin strongly concave. **Gnathopods 1–2:** of medium size, palms almost transverse, dactyls fitting palms. **Pereopods 3–**

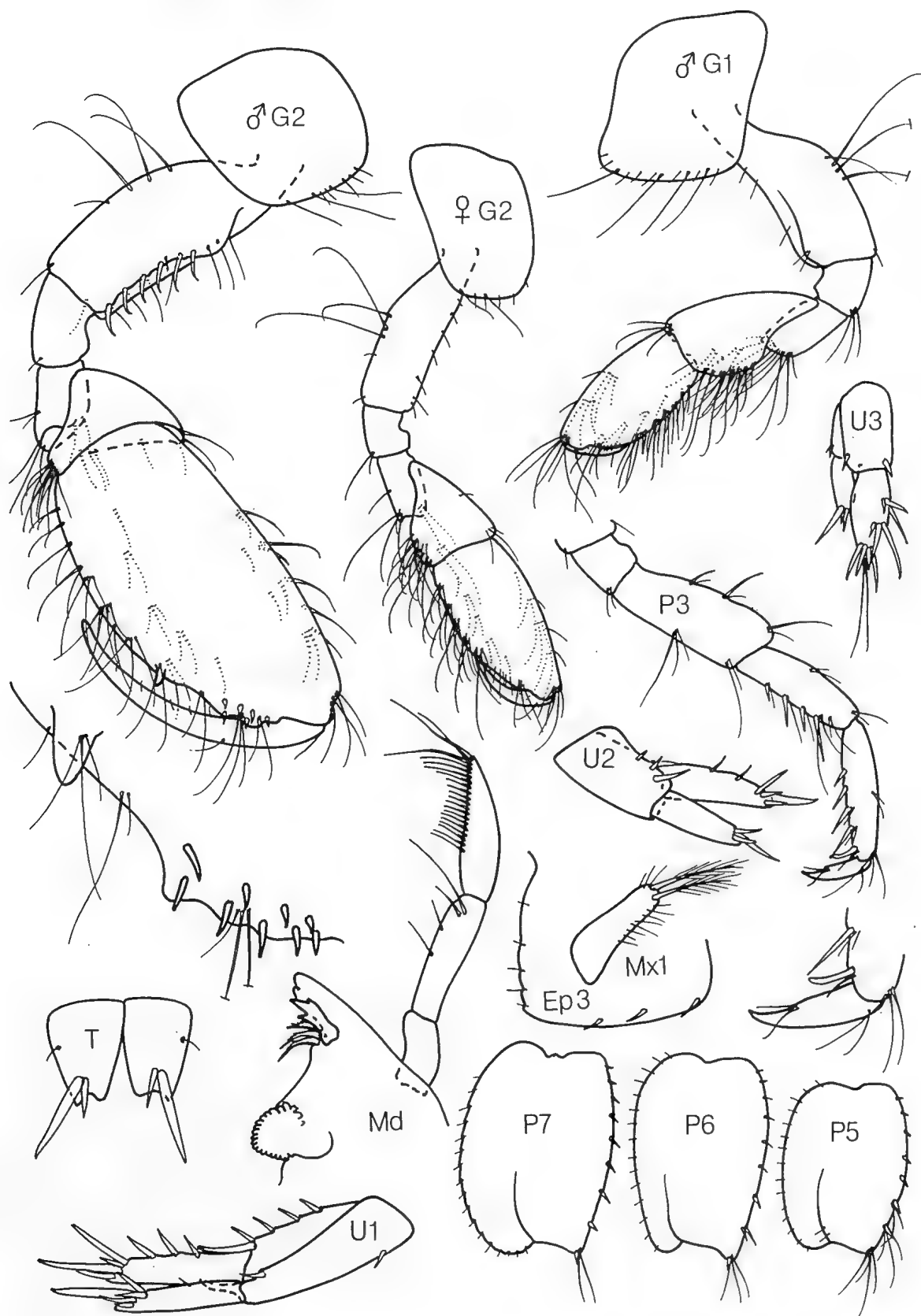


Fig. 2. *Elasmopus aduncus* n.sp. male, 4.2 mm, female 4.0 mm; off Tafunsak Village, Kosrae.

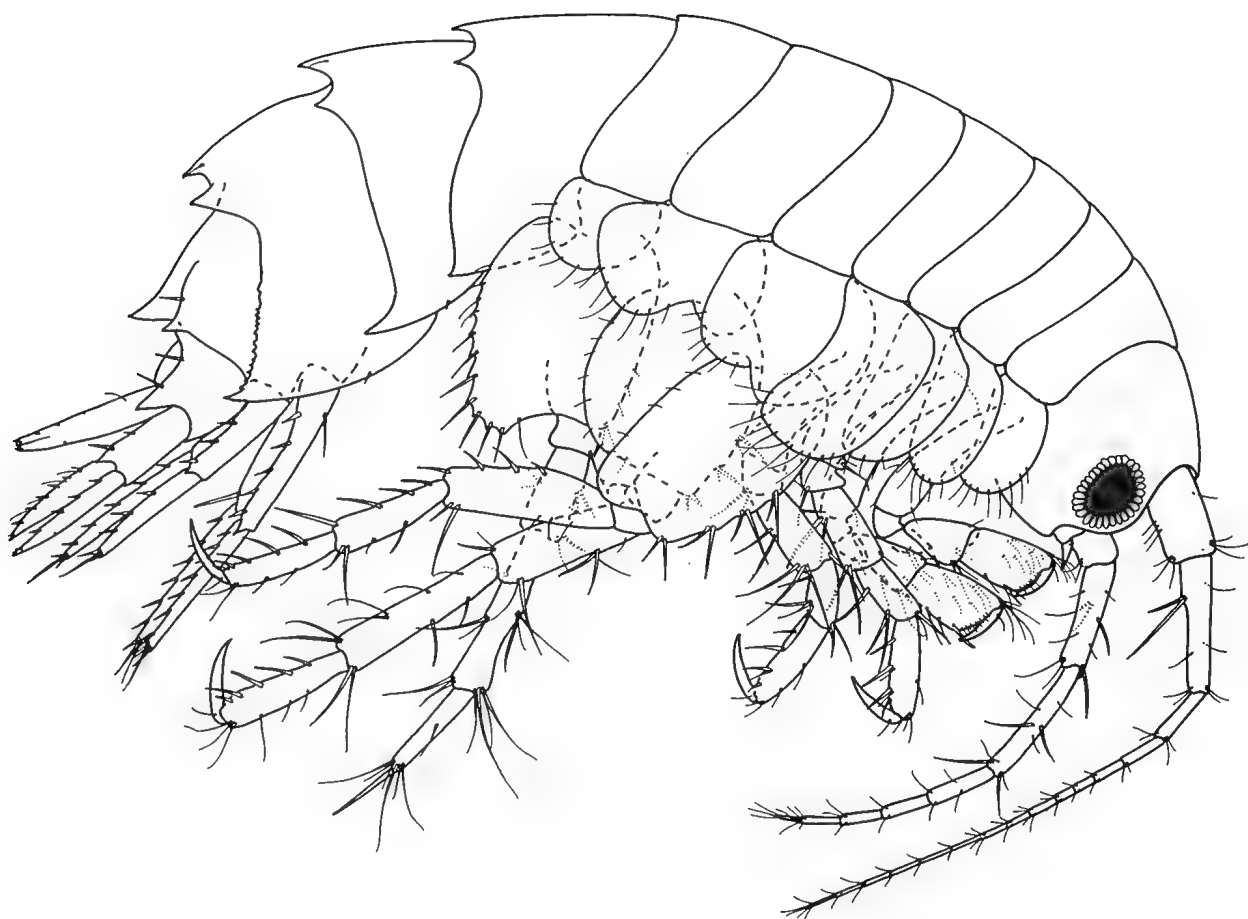


Fig. 3. *Paradexamine tafunsaka* n.sp. female, 2.7 mm; off Tafunsak Village, Kosrae.

4: basis with strongly produced anterodistal lobe, merus, carpus and propodus with strong spines. *Pereopod 5*: basis with well developed rounded posterodistal lobe. *Pereopod 6*: basis expanded, almost as broad as long. *Pereopod 7*: basis posterior margin expanded, crenulate and with a series of strong spines. *Epimera 1-3*: with very well developed, acute distal tooth, lower margins lacking spines, posterior margin of epimeron 3 finely and irregularly crenulate. *Pleon*: segments 1-3 and urosome segment 1 each with a strong dorsal tooth and a lateral tooth on each side (Formula 3.3.3.3.0 following Barnard, 1972), urosome lateral teeth with dorsal spine. Fused urosomites 2+3 also with lateral acute tooth. *Uropod 1*: peduncle longer than rami, with evenly distributed dorsal spines. *Uropod 2*: rami longer than peduncle. *Uropod 3*: rami longer than peduncle, outer ramus with spines, inner ramus with spines and setae. *Telson*: lobes each with apex bearing three small teeth and a spine.

segment 7, in having fewer teeth on the telsonic lobe apices, in having a single spine only, on the lower margin of epimeron 2 and 3, in the broader pereopod 5 basis with evenly rounded posterodistal lobe and in the broad basis of pereopod 6 which is not distally constricted (N.B., P5-6 equals P3-4 of Barnard, 1972). In other respects it is not significantly different from that species. Present material agrees well with material from New Caledonia described under the name *P. windarra* Barnard by Ledoyer (1985). New Caledonian material differs, however, in having a small tooth on pereon segment 7, a markedly serrate pereopod 6 basis and no teeth on the outer plate of the labium. There appear also to be minor differences between New Caledonian and Kosrae specimens in the size and shape of the mesosomal teeth and epimeron 3 serrations. Western Australian material of *P. windarra* measured 3.95 to 4.4 mm, New Caledonian material, 6.0 mm. Both these materials are thus considerably larger than the Kosrae specimens. *Paradexamine tafunsaka* differs from the only other known Micronesian species, *P. orientalis* (Barnard, 1965) (not Spandl, 1924) in the round eye-lobes, distally expanded and spiny pereopod 7 basis, broad outer

**Remarks.** *Paradexamine tafunsaka* is very close to *P. windarra* Barnard, 1972 from Western Australia. It differs in the absence of any teeth on pereon

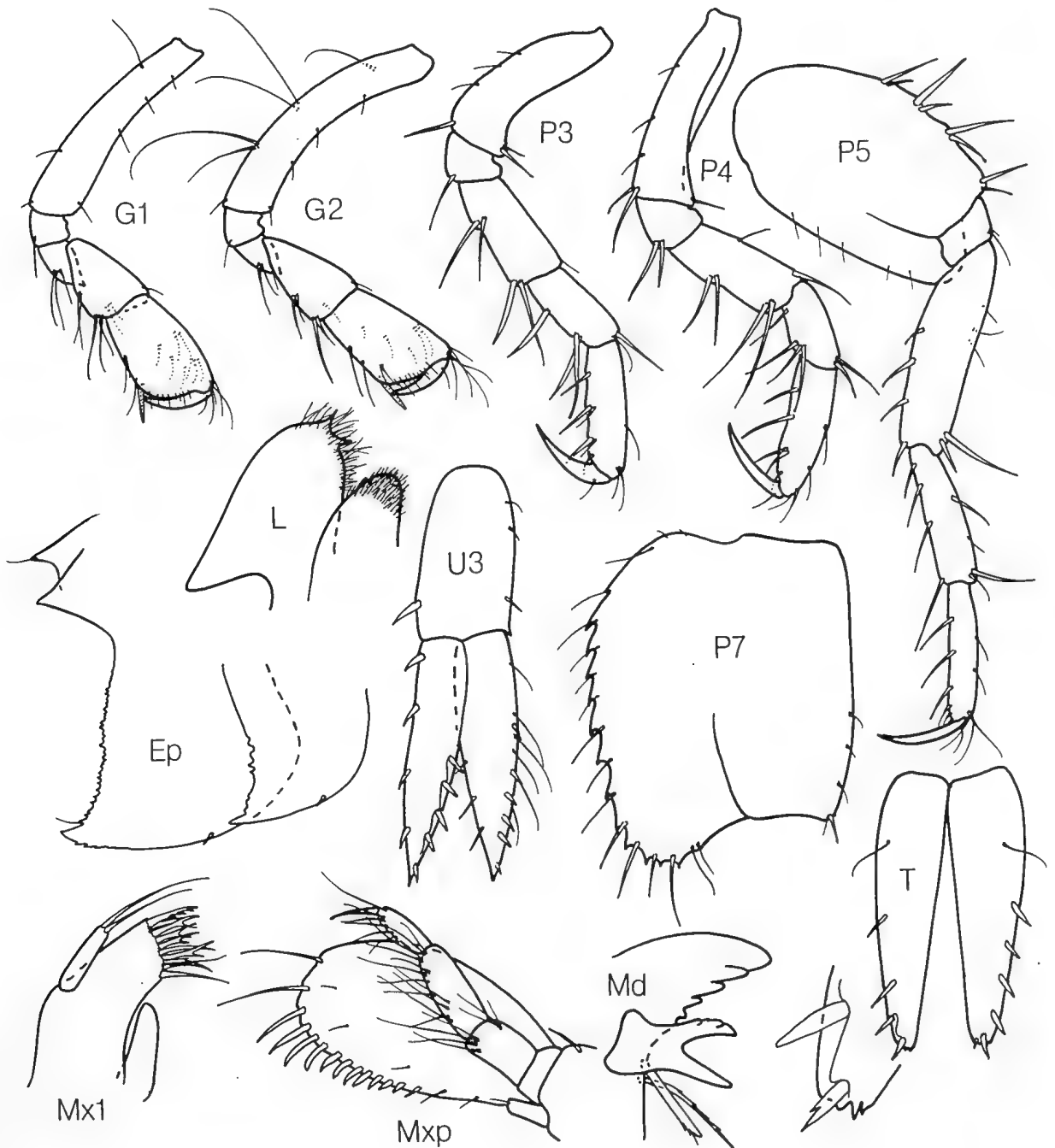


Fig. 4. *Paradexamine tafunsaka* n.sp. female, 2.7 mm; off Tafunsak Village, Kosrae.

plate of the maxilliped, short inner plate of maxilla 2, few-toothed telsonic apices and presence of lateral teeth on pleon segment 4. This last character was not described by Barnard (1965) but, as judged from his figure (25a) such teeth are absent. Ledoyer (1982) erected a new species, *P. micronesica* Ledoyer, for material from Tuléar in Madagascar and tentatively synonymised Barnard's Micronesian material of

*Dexaminoides orientalis* with this species. Clarification of the status of *D. orientalis* Barnard (not Spandl) requires confirmation when more Micronesian material of the species becomes available.

**Etymology.** Named after the type locality.

*Gammarella utwe* n.sp.

Figs 5, 6

**Type material:** HOLOTYPE male, 4.5 mm, AM P42700, Utwe Harbour (5°17'N 162°59'E), among *Thalassia hemprichii* and *Enhalus acoroides*, less than 1 m depth, 30 June 1991, stn 2. PARATYPES (40) AM P42698 same data as holotype.

**Description.** Length to 4.5 mm, male, 6.0 mm, female. *Head:* with subocular notch, eye small. *Antenna 1:* about half body length, peduncular articles in the basodistal ratios 7:7:3, weakly setiferous, flagellum longer than peduncle with about 28 articles, accessory flagellum with four articles. *Antenna 2:* two-thirds length of antenna 1, peduncular article 4 longer than article 5, flagellum equal to combined length of peduncular articles 4+5, with about 20 articles. *Mandible:* triturative, palp article 2 the longest, article 3 slender, narrowing distally. *Maxilla 1:* inner plate densely setose along its inner margin. *Gnathopod 1:* slender, carpus much longer than propodus, setose, propodus palm short, oblique, with spine-setae, dactylus fitting palm. *Male gnathopod 2:* basis enlarged, carpus very reduced, cup-shaped, nearly three times as broad as long, propodus massive, over two times as long as broad, posterior margin straight or slightly concave, anteriorly with a small declivity and five peg-like spines, palm almost obsolete, defined by a pair of stout, small spines, dactylus enlarged, falciform nearly two-thirds length of propodus. *Female gnathopod 2:* basis slender, four times as long as broad, carpus and propodus slender, propodus slightly the longer, palm very oblique, defined by a small spine, dactylus fitting palm. *Pereopods 3-4:* slender, propodus posterior margin with a series of spines. *Coxa 4:* largest, posterior margin evenly concave. *Pereopods 5-6:* basis sub-pyriform, posterior margin with weakly concave and weakly crenulated flange, anterior margin spinose. *Pereopod 7:* basis with huge, convex, crenulated flange. *Epimeron 1:* rounded. *Epimeron 2:* with weak posteroventral tooth. *Epimeron 3:* with weak posterodistal tooth and weakly crenulated posterior margin. *Uropods 1-2:* stout, spinose. *Uropod 3:* short, outer ramus subequal with peduncle, with a strong, triangular second article, with strong spines at its base together with an outer marginal spine, inner ramus half length of outer ramus, triangular, lacking spines. *Telson:* cleft nearly to base, with a pair of spine-setae on the anterodistal margins, each apex with a weak concavity and a fine seta.

**Remarks.** This species is most closely allied to those *Gammarella* species which were originally attributed to the genus *Cottesloe* Barnard. It differs from other described species of this sub-group in the complete absence of any dorsal keels on the pleosome or urosome segments. It most closely resembles *Gammarella* (= *Cottesloe*) *berringar* (Barnard, 1974), from warm-temperate Australia, but that species has a strong acute keel

on urosome segment 1, an apparently slender basis on the male gnathopod 2, a falcate mandibular palp and several other minor differences. It also resembles the northern hemisphere *G. fucicola* (Leach, 1814) but that species has a urosomal keel and a different male gnathopod 2 (slender basis, strongly setose carpus and very long dactylus). This is the first record of the genus from Micronesia.

**Etymology.** Named after the type locality.

*Cerapus micronesicus* n.sp.

Fig. 7

**Type material:** HOLOTYPE male, 3.5 mm, AM P42699, Utwe Harbour (5°17'N 162°59'E), among *Thalassia hemprichii* and *Enhalus acoroides*, less than 1 m depth, 30 June 1991, stn 2.

**Description.** *Head:* rostrum acute, about one quarter length of peduncular article 1 of antenna 1, lateral cephalic lobes with subacute anteroventral corners. Body elongate, cylindrical. *Antenna 1:* well developed, setose, about half body length, peduncular articles 1-3 subequal in length, article 1 expanded posteroproximally, flagellum half length of peduncle with 5 articles. *Antenna 2:* well developed, setose, subequal in length with antenna 1, peduncular article 5 longer than 4, flagellum half length of peduncle, with 5 articles. *Mandible:* molar triturative with well developed flake, lacinia mobilis multidentate, palp article 3 a little shorter than article 2, slender with about 10 long setae on posterior and distal margins. *Maxilla 1:* inner plate small, with a single relatively short simple distal seta, palp with six apical spines and a row of five subapical setae. *Maxilla 2:* outer plate broader than inner, inner plate with numerous apical setae, a row of subapical setae and a few marginal setae. *Labium:* mandibular processes subacute. *Gnathopod 1:* subchelate, carpus with lobate posterodistal margin, propodus very oblique, dactylus fitting palm. *Male Gnathopod 2:* carpochele, basis swollen, about 1.5 times as long as broad, carpus enlarged, subtriangular, with large, acute, outwardly deflected posterodistal tooth, separated from a small, triangular medial tooth, by a round-bottomed excavation, propodus slender, about three times as long as broad, dactylus stout, elongate, two-thirds length of propodus. *Pereopods 3-4:* basis swollen, twice as long as broad and as long as combined length of articles 3-7. *Pereopod 5:* short, coxa 1.3 times as broad as deep, with a small posterior lobe, basis a little longer than broad, merus posterior lobe with long setae, exceeding combined lengths of articles 5-7, carpus telescoped into merus, dactylus uncinatate with accessory tooth on anterior margin. *Pereopod 6:* slender, basis almost twice as long as broad, merus,

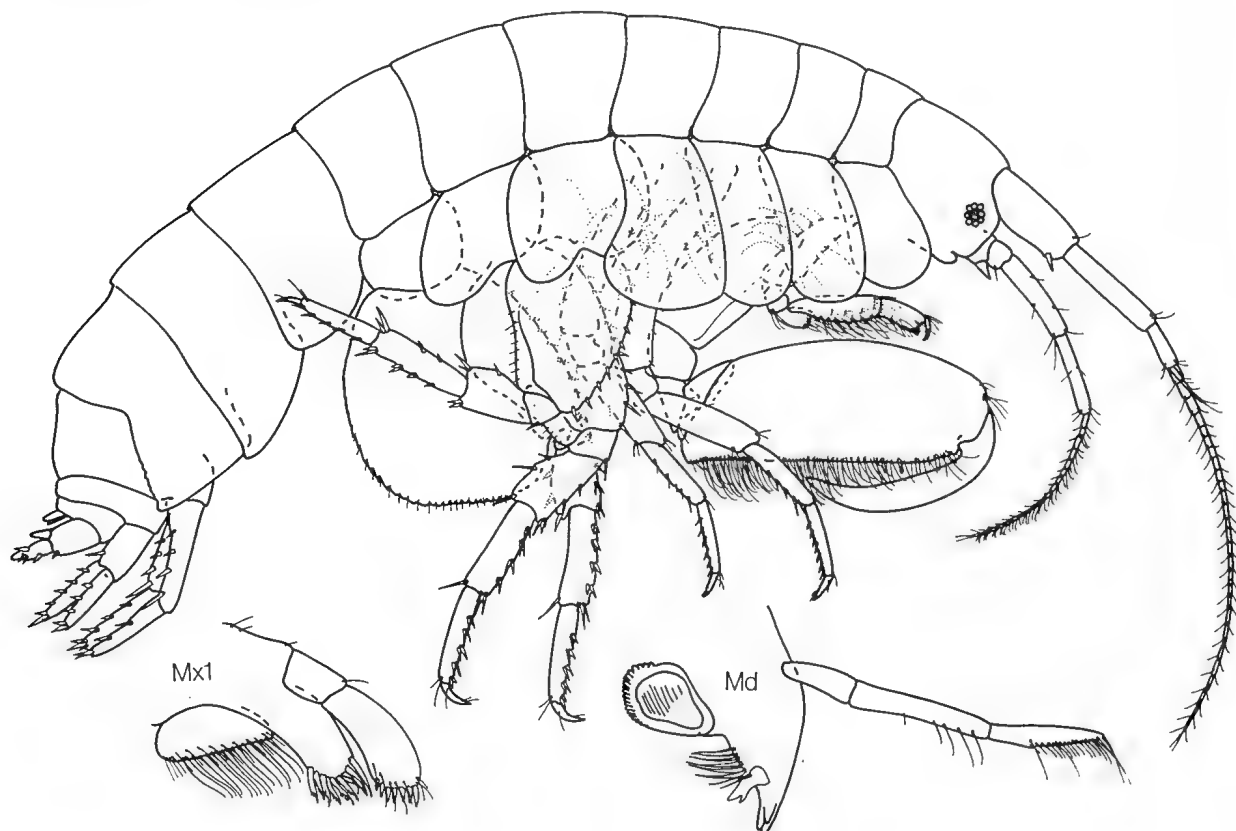


Fig. 5. *Gammarella utwe* n.sp. male, 4.5 mm; Utwe Harbour, Kosrae.

carpus and propodus elongate, carpus posterodistal margin with very long setae which greatly exceed combined lengths of propodus and dactylus, propodus with long distal setae, dactylus unciniate with accessory tooth. *Pereopod 7*: similar to pereopod 6, but merus, carpus and propodus all with very long distal setae. *Pleopods 1–3* decreasing in size, pleopod 3 inner ramus half length of outer ramus, outer ramus elongate and terminally narrow. *Uropod 1*: biramous, peduncle three times as long as broad, distally pectinate, outer ramus outer margin finely denticulate and with a few setae, with one large distal spine surrounded by minute spines, inner ramus half length of outer with a large distal spine surrounded by minute spines. *Uropod 2* uniramous, ramus weakly unciniate, asetose and less than one fifth length of peduncle. *Uropod 3*: uniramous, peduncle expanded about two-thirds as broad as long, ramus small, biuncinate. *Telson*: completely cleft, each lobe with a cluster of spines.

Female unknown.

known in any other species of the genus. It does however, differ in several ways which seem to warrant specific recognition. The antennal flagella are relatively longer, the rostrum, although well developed is shorter than in *C. oceanicus*, the male gnathopod 2 is of different shape, the large carpal tooth is outwardly deflected, the small tooth is poorly developed and the propodus is very slender and pleopod 1–3 outer ramus is more elongate and slender and uropod 3 peduncle is less elongate and more swollen.

Some of the differences noted above, for example relative differences in the lengths of antennal articles, may be related to the small size of the present material (3.5 mm, as opposed to 6.1 mm to 6.8 mm in Samoan material). However, the male gnathopod 2 of present material appears quite mature and is very different from the developing (5.0 mm) male gnathopod 2 of *C. oceanicus* figured by Lowry (1985, fig. 8a). The Kosrae specimen does not therefore appear to be merely a juvenile of *C. oceanicus*, but to be an adult of a more diminutive species.

**Remarks.** This species is undoubtedly very close to *C. oceanicus* Lowry, 1985. Notably it shares with that species, a completely cleft telson, a character state not

**Etymology.** From its collection site in Micronesia.

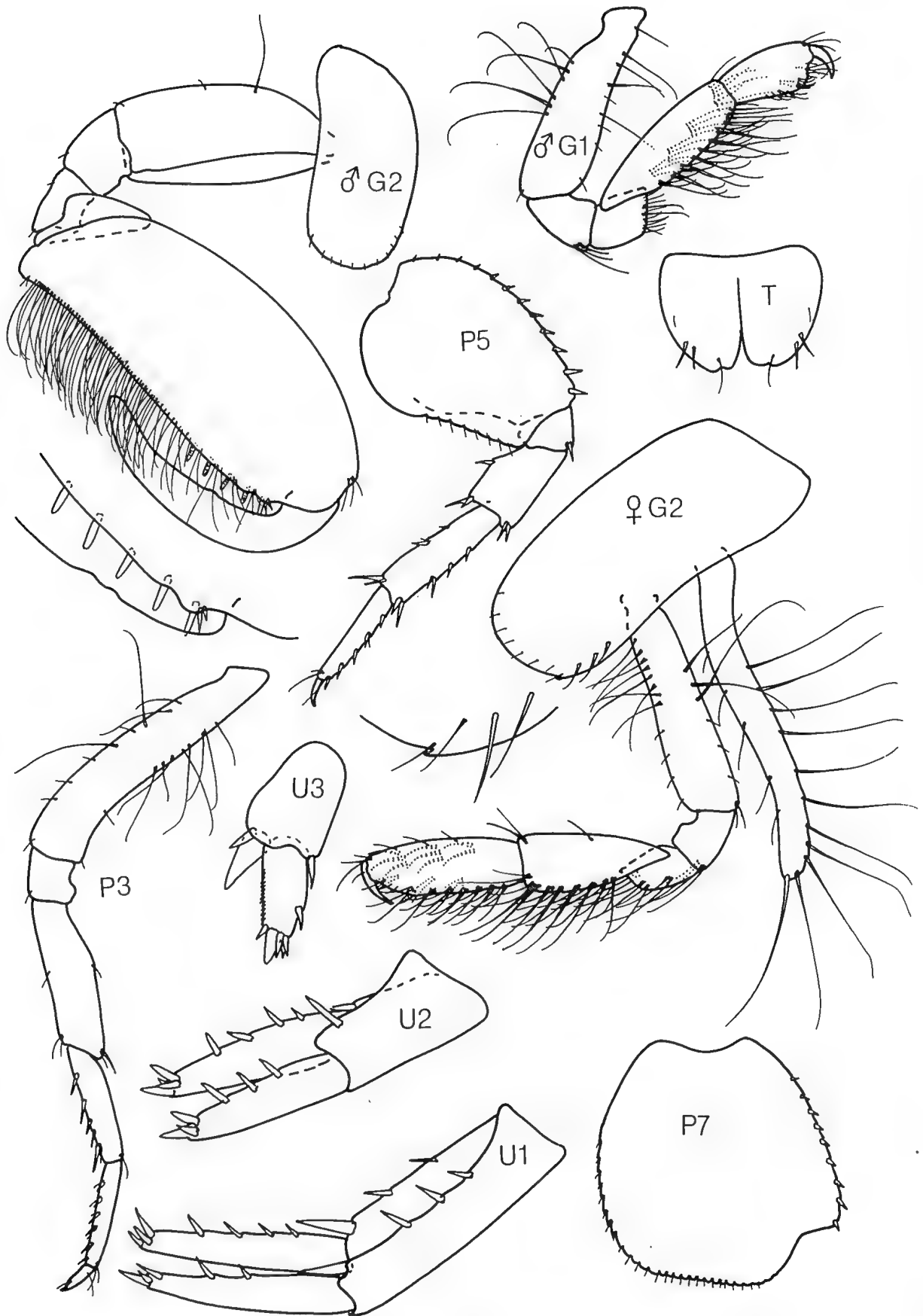


Fig. 6. *Gammarella utwe* n.sp. male, 4.5 mm, female 5.8 mm; Utwe Harbour, Kosrae.



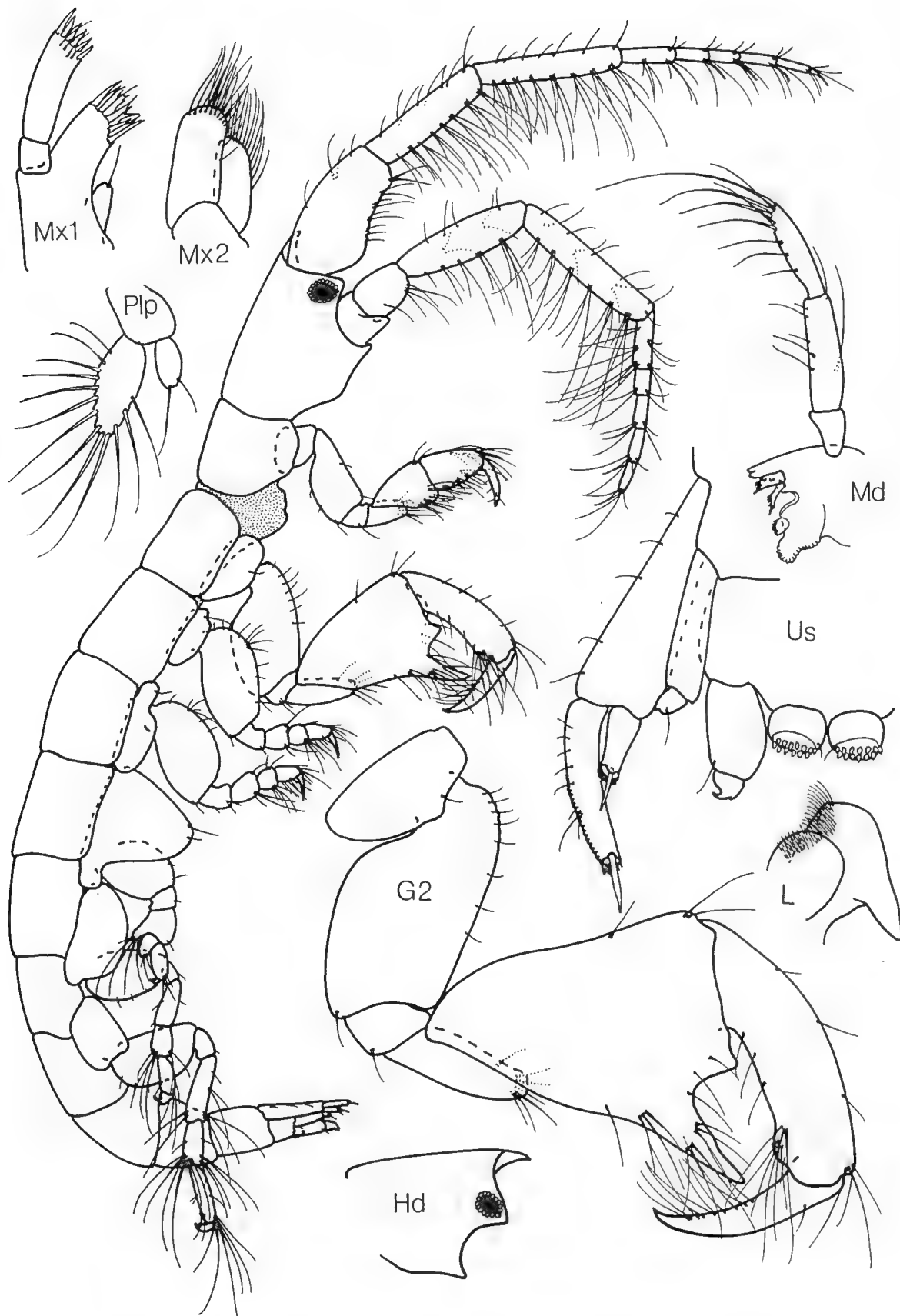


Fig. 7. *Cerapus micronesicus* n.sp. male, 3.5 mm; Utwe Harbour, Kosrae.

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## APPENDIX 1

## Station dates:

- Stn 1.** Utwe Harbour (5°17'N 162°59'E), from artificial rope-fibre habitats among *Thalassia hemprichii* and *Enhalus acoroides*, *in situ* for two months, less than 1 m depth, 28 October 1990.
- Stn 2.** Utwe Harbour (5°17'N 162°59'E), among *Thalassia hemprichii* and *Enhalus acoroides*, less than 1 m depth, 30 June 1991.
- Stn 3.** Tafunsak Village (5°22'N 163°02'E), rope-fibre tied to coral, 5 m depth, 28 October 1990.
- Stn 4.** Tafunsak Village (5°22'N 163°02'E), rock washings from exposed reef-flat, less than 1 m depth, 16 July 1991.

## APPENDIX 2

## Annotated list of species recorded from Kosrae

Family	Species	Males	Females	Immature	Stn No.
HYALIDAE	<i>Hyale galateae distorta</i> Myers	2	3		3
MELITIDAE	<i>Elasmopus alalo</i> Myers	14	6		3
		1			4
	<i>Elasmopus gracilis</i> Schellenberg	6	3		4
	<i>Elasmopus aduncus</i> n.sp.	10	10	1	4
	<i>Elasmopus hooheho</i> Barnard	13	7	2	1
	<i>Elasmopus setiarpus</i> Myers	1	3		4
	<i>Maera pacifica</i> Schellenberg	2			1
		1			2
	<i>Maera quadrimana</i> (Dana)	2			3
	<i>Maera serrata</i> Schellenberg	1			3
	<i>Mallacoota subcarinata</i> (Haswell)	1			1
	<i>Melita celericula</i> Croker	16	23		2
			1		1
	<i>Parelmopus suensis</i> (Haswell)	1			2
Un-named family	<i>Gammarella utwe</i> n.sp.	16	19	6	2
DEXAMINIDAE	<i>Paradexamine tafunsaka</i> n.sp.		2		3
AMPITHOIDAE	<i>Ampithoe kuala</i> Myers	16	24		3
	<i>Cymadusa brevidactyla</i> (Chevreux)	6			1
	<i>Cymadusa imbroglia</i> Rabindranath	7	12		1
	<i>Cymadusa filosa</i> Savigny	1			4
	<i>Cymadusa pilipes</i> (Ledoyer)	3	7		4
	<i>Paragrubia vorax</i> Chevreux		1		1
		9	17		3
	<i>Pleonexes kulafi</i> Barnard	7	12		3
ISAEIDAE	<i>Gammaropsis digitata</i> (Schellenberg)	55	72		4
ISCHYROCERIDAE	<i>Cerapus micronesicus</i> n.sp.	1			2
AORIDAE	<i>Grandidierella bonnieroides</i> Stephensen	11	15		1
		23	19		2
PODOCERIDAE	<i>Podocerus talegus</i> Barnard	2	2		3

## A Review of the Stenetriidae (Crustacea: Isopoda: Asellota)

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**ABSTRACT.** The current classification of the Stenetriidae includes five genera and 63 species, of which 57 species are contained in the genus *Stenetrium* Haswell, 1881. A history of the classification of the family Stenetriidae is reviewed and useful characters for defining stenetriid taxa and species are derived from the literature. A new diagnosis for the family is provided. *Stenetrium* is redefined and its composition reduced to 18 species. The type species of *Stenetrium*, *S. armatum* Haswell, 1881, is fully redescribed. A new species, *Stenetrium adrianae*, is described in this paper, highlighting morphological variation that can be useful for distinguishing stenetriid taxa. Three other named genera, *Stenobermuda* Schultz, 1979a (*Stenetrigus* Schultz, 1982 is a junior synonym), *Protallocaloxa* Schultz, 1978, and *Tenupedunculus* Schultz, 1982, are redefined and their compositions adjusted. Four new genera, *Tristenium*, *Hansenium*, *Liocoryphe*, and *Mizothernar*, are erected to contain distinctive species groups not treated in the literature. Six species are poorly described and cannot be classified in this new arrangement for the family. Lists of species assigned to each group and a key to the genera are provided.

SEROV, P.A. & G.D.F. WILSON, 1995. A review of the Stenetriidae (Crustacea: Isopoda: Asellota). Records of the Australian Museum 47(1): 39–82.

The isopod family Stenetriidae Hansen, 1905 occupies a central role in the understanding of the suborder Asellota. The disagreement between Wägele (1982, 1989) and Wilson (1987) on stenetriid sister group relationships highlights this family's importance. Although the Stenetriidae shares apomorphies with more derived Asellota (Wilson, 1987), the Stenetriidae also contain important variation in the male pleopods, sometimes resembling members of two other asellote families, the Gnathostenetroididae Kussakin, 1967 and the Pseudojaniridae Wilson, 1986a. Unlike most non-janiridae families of Asellota, the Stenetriidae range from tropical to polar shallow marine waters (Kussakin, 1973; Hessler *et al.*, 1979), thus occupying

possible ancestral habitats for the Asellota. Despite being a potentially rich source of phylogenetic information on asellote relationships, the Stenetriidae has received little revisionary attention. Our paper redresses this situation.

After Hansen's (1905: 303) description of the family, Wolff (1962) provided the only comprehensive examination of stenetriid species, but encountered barriers to understanding their interrelationships. The overall similarity of most species made the division of stenetriid taxa difficult. Wolff (1962: 21) stated that "on the whole, *Stenetrium* is no doubt exceedingly homogenous." This apparent homogeneity, however, was often caused by "short, insufficiently detailed

descriptions and illustrations by some authors" (Wolff, 1962: 22). Owing to these problems, Wolff (1962: 22) stated "that several species are very close to each other and some others are probably identical" even though the species are widely separated geographically. He encountered the greatest difficulty in separating the following species: *Stenetrium armatum* Haswell, 1881 (south-eastern Australia) and *S. dalmeida* Barnard, 1920; *S. diazi* Barnard, 1920 (South Africa); *S. stebbingi* Richardson, 1902 (Bermudas) and *S. antillense* Hansen, 1905 (West Indies); *S. chiltoni* Stebbing, 1905 (Indian and Pacific Oceans) and *S. glauerti* Nicholls, 1929 (Western Australia); *S. medipacificum* Miller, 1941 (Pacific Ocean) and *S. dagama* Barnard, 1920 (South Africa).

The synonymies proposed for stenetriids (see Wolff, 1962) exemplify the lack of understanding of their high species diversity and parochial distributions. *Stenetrium armatum* Haswell, 1881, is a classic example of these misconceptions. *Stenetrium armatum* was first described only from Port Jackson, Sydney, eastern Australia. Since that time, all similar specimens from south-eastern Australia have been identified as this species. The most recent redescription of *S. armatum*, stated that the species "is distributed in south-eastern Australia from at least Port Stephens, central New South Wales..., to the Gulf of St Vincent, near Adelaide, South Australia" (Schultz, 1982). Our extensive examination of all specimens of *Stenetrium* held by the Australian Museum and the Museum of Victoria revealed that the above range encompasses as many as 20–30 species. Most previous synonymies, therefore, are in doubt.

An ongoing revision of the Asellota (e.g., Wilson, 1994; Wilson & Wägele, 1994 for the janiroidean family Janiridae) will assess the phylogenetic position of the Stenetriidae within the suborder. This paper begins this work with a review of stenetriid morphology and taxonomy. We provide a brief overview of the history of stenetriid classification, and then discuss the distinguishing features of the Stenetriidae and their character variation. In the taxonomic section, we provide diagnoses and synonymies for existing genera and describe four new genera: *Tristenium*, *Hansenium*, *Liocoryphe*, and *Mizothenar*. Descriptions of the type species of *Stenetrium*, *S. armatum* Haswell, 1881 and a new species, *S. adrianae*, demonstrate useful species-level character variation.

### History of the Stenetriidae

Haswell (1881) placed two species in his new genus *Stenetrium*, *S. armatum* and *S. inerme*, both collected from Port Jackson at Sydney, Australia. *Stenetrium inerme* was later referred by Stebbing (1905) to the janiroidean genus *Notasellus* Pfeffer, 1881 (= *Iathrippa*: see Wilson & Wägele, 1994). The first stenetriid species was described by Lucas (1849) as *Jaera longicornis* from Algeria, later found at Lesina in the

Adriatic by Heller (1866). Bovallius (1886) established the genus *Jamna* for this species, noting marked differences of the included species *Jaera longicornis* and *Jaera filicornis* Grube, 1861 with other species of *Jaera*. Beddard (1886) also suggested that *Jaera longicornis* had been incorrectly placed within *Jaera*, but did not give an alternative classification. The junior synonym for *Stenetrium*, *Jamna*, was used by Stebbing (1893) but later its species were referred by Richardson (1910) to *Stenetrium*.

Between 1881 and 1910, 13 stenetriid species were described. Hansen (1905) published a summary and revision of *Stenetrium* and proposed the family Stenetriidae. Wolff (1962) summarised the knowledge on stenetriids, including their taxonomy and distribution, and created the superfamily Stenetrioidea. In the period since 1962, 27 stenetriid species have been described, along with 4 new genera. *Protallocoxa* Schultz, 1978, was presented as an example of a new superfamily, but was later shown to be a taxon consisting of female *Stenetrium* specimens (Wilson, 1980). *Stenobermuda* Schultz, 1979a and *Stenetrigus* Schultz, 1982, were created for species from Bermuda and South Africa respectively, although we find below that these two genera are synonymous. *Tenupedunculus* Schultz, 1982 is a blind deep water form that is related to southern hemisphere, shallow water *Stenetrium* (sensu lato) species.

### Informative Characters of the Stenetriidae

The structures used to distinguish taxa, especially the pereopod I and male pleopod II, have diagnostic potential and are possibly phylogenetically informative. Our findings concern within-stenetriid relations; more detailed research will be required to place these taxa in a broader context of other lower Asellota (Aselloidea, Gnathostenetroidoidea, Protojaniroidea, Pseudojaniridae, Vermectiadiidae). In the following, we discuss our observations on characters of stenetriid species, based both on specimens in our collections and from those described in the literature. In many cases, we have inspected types described in the literature. Table 1 provides a list of genera and species mentioned in this paper. The taxonomic section provides explicit diagnoses of all genera, including the four new ones. Comparative illustrations for the genera can be found in Figures 1–3.

Pereopod I (Fig. 3). The subchelate, sexually dimorphic pereopod I is the most prominent feature of the Stenetriidae and the most commonly used character in defining species. The male pereopod I has a large, ovoid propodus opposed by an elongate dactylus. The propodal palm varies considerably by possessing either a row of denticulate setae and terminating spine-like seta defining the end of the palm, or various arrangements of blade-like spines or a combination of both. The female pereopod is

generally much smaller, unornamented and similar throughout the family, making identification of species from females on this basis difficult.

The length of the dactylus relative to the length of the propodal palm in males is useful: the dactylus is longer than the distal width of the propodus in *Stenetrium armatum*, *S. diazi*, *S. vema* Kensley, 1980, *S. esquartum* Schultz, 1982, and *S. bartholomei* Barnard, 1940. The carpus, merus and ischium of the pereopod I are short and robust and vary considerably at the species level in the degree of setation and dorsal margin spination. *Stenobermuda acutirostrata* (Richardson, 1902) has the most unusual male pereopod I within the family owing to the following features: the small size of the propodus; the large terminal setae on the propodal palm; and elongate carpus, merus and ischium.

The female pereopod I (Figs 8A,B, 20A,B) may be distinguished at the species level by setal type, arrangement and number on the opposing edges of the propodus and dactylus, and the setation of the carpus, merus and ischium. The remaining pereopods II–VII do not differ significantly throughout the Stenetriidae, apart from setal patterns.

Sternal spines or keels (Figs 4A,B, 15C). Another strong sexually dimorphic character of the Stenetriidae is the simple spinose projections along the midline of the sternum of some males. Wolff (1962: 25) refers to them as "hyposphenians" but here they will be termed sternal keels owing to their laterally flattened shape. The presence of the keels as well as their absence (e.g., in *Stenetrium abyssale* Wolff, 1962) has been mentioned by authors as far back as Hansen (1905), although no taxonomic significance was given to this feature. The keels have been illustrated in only *Stenetrium maharepa* Müller, 1991a, and *Stenetrium macrochirum* Nicholls, 1929 (p. 362, his fig. 1). Size, shape, direction of individual keels may vary. The keels are usually directed anteriorly on pereonites 1–4 and posteriorly on pereonites 5–7. This arrangement is unique to Stenetriidae. Other Asellota have sternal keels on only one segment (*Rapaniscus*, *Nannoniscus*, *Ianiropsis* and *Storhyngura*) or on all pereonites such as *Macrostylis*. These spines differ, however, in direction and position on the pereonites from those seen in the Stenetriidae. The degree to which keels can be used diagnostically is yet to be determined, as they have not been illustrated extensively in the literature.

Eyes (Figs 1, 2). Eye morphology varies considerably in the stenetriids by shape, size, number of ocelli and position on the cephalon. The most common eye form of the Stenetriidae is the anterolateral reniform shape containing about 20 ocelli, as seen in *Stenetrium* sensu stricto, *Tenupedunculus* Schultz, 1982, and *Hansenium* n.gen. The remaining species possess either eyes of as few as 4 ocelli (e.g., *Liocoryphe* n.gen. and *Stenobermuda* Schultz, 1979a), or small groups of about 8–10 ocelli (e.g., *Stenetrium patulipalma* Kensley, 1984a and *S. acutirostrum* Müller,

1991b). We do not recognise *Tenupedunculus* as a genus using the absence of eyes alone as was done by Schultz (1982). Although genera cannot be distinguished by the presence or absence of eyes, the consistency of eye form within the proposed new genera suggests that eyes may be used to distinguish species and genera.

Caution is required when using eyes as a feature owing to ontogenetic variation. Early manca of some species have a circle of few ocelli similar to *Stenetrium minocule*, which develop into the characteristic reniform shape eye by the subsequent addition of ocelli anteromedially. Heterochrony, therefore, may be important in the ontogeny and phylogeny of the stenetriids.

Cephalon Projections. The cephalic projections (spines) and the mouthparts may offer important diagnostic features of the cephalon. Cephalic projections include lateral and antennal spines and the rostrum. The antennal spine is defined as a spine-like extension of the anterior margin of the cephalon between the antennula and the antenna. The lateral spines, then, are the spine-like extensions lateral to the antennule. The Stenetriidae and related families (Gnathostenetroididae, Pseudojaniridae) differ in this regard in that they either lack one or the other of these spines. The lateral spines are large and robust while the antennal spines are missing in Pseudojaniridae. In the Gnathostenetroididae, the antennal spines are reduced and the lateral spines are absent.

The rostrum is defined as any anterior extension from the frons or vertex of the cephalon. Shape and armature varies between species, although rostral sizes do not. Schultz (1982) stated that the rostrum of *Stenetrium armatum* varies from broadly rounded to produced independently of sex, although our research shows he was comparing several species. The serrations on the rostrum in *S. armatum* and *S. adrianae* n.sp. are not sexually dimorphic and do not vary ontogenetically except the serrations (when present) are more pronounced in larger animals.

Antennula (Figs 5C, 16D,E) and antenna (Figs 19A–C). These limbs vary in size and shape of the peduncular articles, the number and size of flagellar articles, and number and position of aesthetascs and setae on the flagellar articles. The number of flagellar articles also varies ontogenetically making this feature less useful at the generic level. A large lateral spine on the antennular article 1 is a distinctive feature of the *Stenetrium* sensu stricto.

Mouthparts (Figs 6, 7, 18, 19D–F). The mouthparts are relatively constant throughout the family. The mandible shows principally species distinguishing setal numbers and arrangements on the second article of the palp, the number of spines in the spine row, the denticles and setae around the molar process. Observed differences in size, shape and number of denticles of the grinding surface of the molar process is of undetermined taxonomic significance.

Wolff (1962) stated that the maxillula and the maxilla do not vary greatly during the postmarsupial develop-

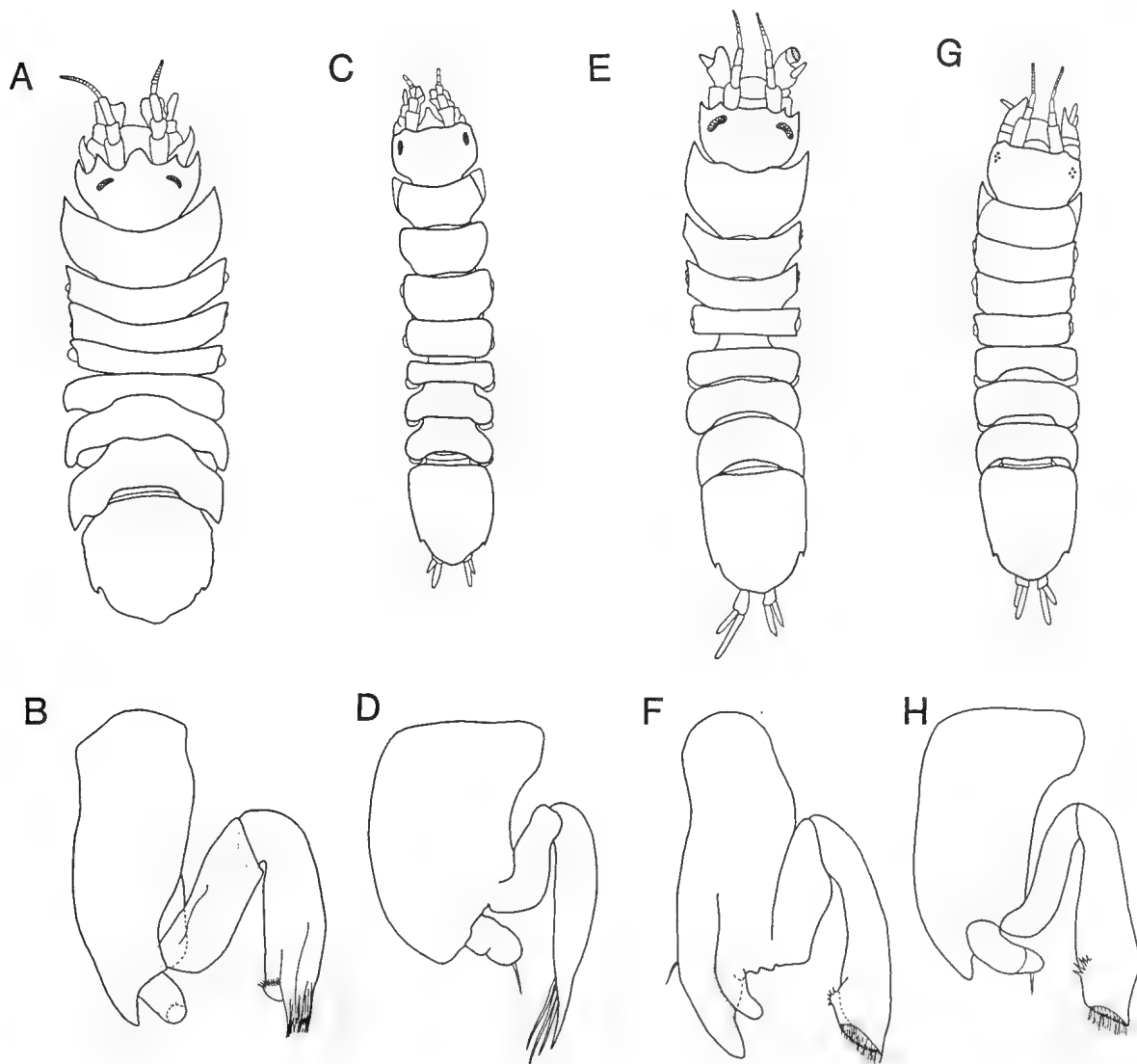


Fig. 1. Stenetriid genera showing body form and male pleopod II. A,B, *Stenetrium* Haswell sensu stricto. C,D, *Tristenium* n.gen. (after Müller, 1991c, figs 1, 13). E,F, *Hansenium* n.gen. (after Menzies & Glynn, 1968, fig. 34). G,H, *Liocoryphe* n.gen. (after Müller, 1990, figs 1, 14).

ment. Throughout the Stenetriidae, various setal types of both structures differ in number and size. Exact setal counts for each structure are difficult to determine owing to the poor illustrations of many species. These structures may yield useful information.

The most useful characters on the maxilliped are the epipod, the palp articles, and the fan setae on the distal margin of the endite. The distal tip of the stenetriid epipod typically extends to or beyond palp article 3 and varies principally in marginal setation and distal tip shape. The epipod shape ranges from a typically pointed, tapered tip with an angular corner on the lateral margin (e.g., *Stenetrium armatum*), to a rounded tip (e.g., *Stenetrium abyssale*), or to an

epipod with smooth lateral margins (e.g., *Stenobermuda acutirostrata*).

The maxillipedal endite distal margin has a complex arrangement of 3 rows of differing setae, with the middle row consisting of principally broad, fan shaped setae that vary in number and size between species and may be important at higher taxonomic levels. Unfortunately, most illustrations in the literature do not show these setae in sufficient detail.

Pereopodal Coxae. Visible coxal projections, spines or lobes are visible dorsally on pereonites 1–4 and posteriorly on pereonites 5–7. The projections range from double lobes on pereonites 2–4 and large single posterolateral lobes on the remaining pereonites (as



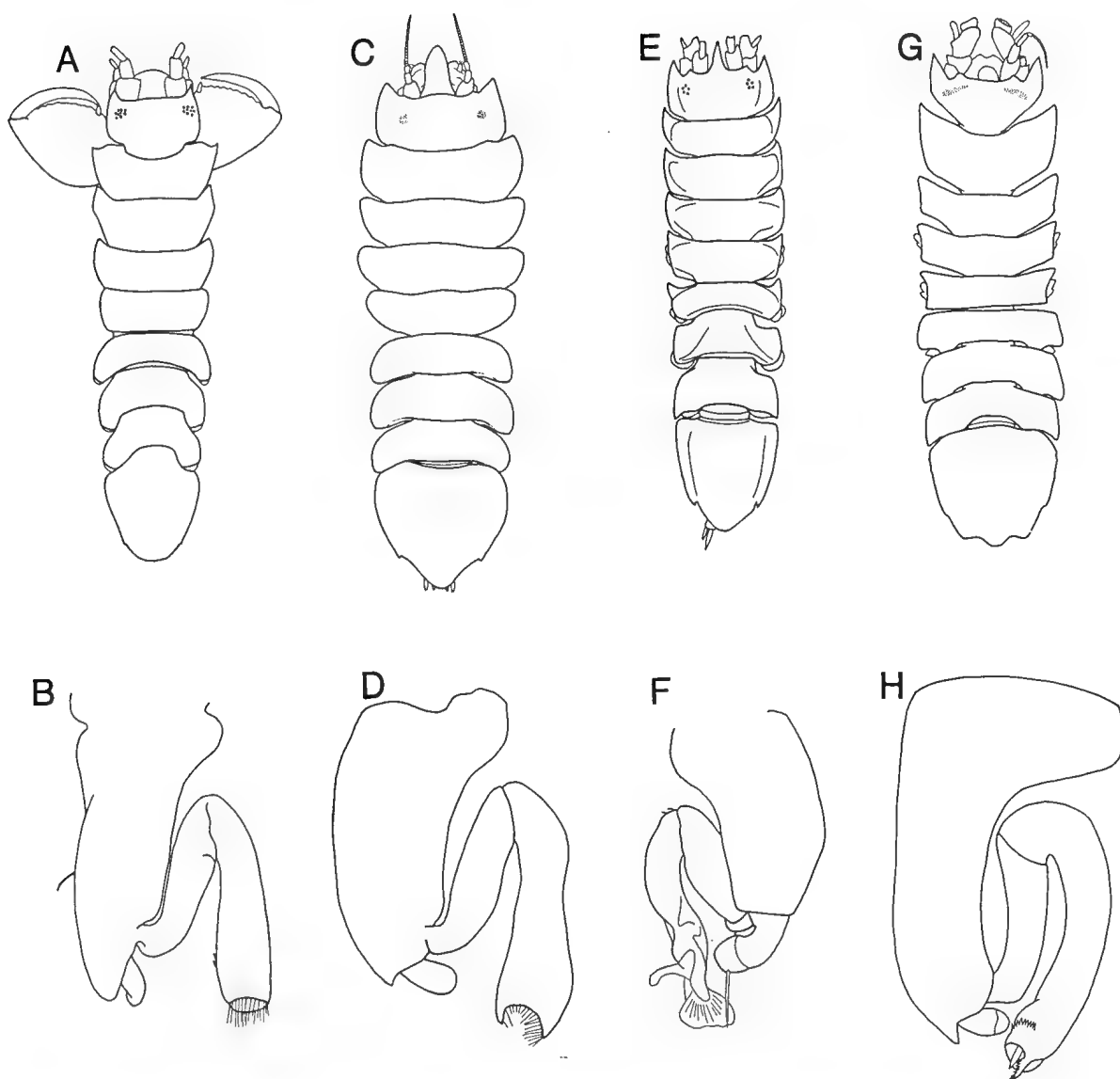
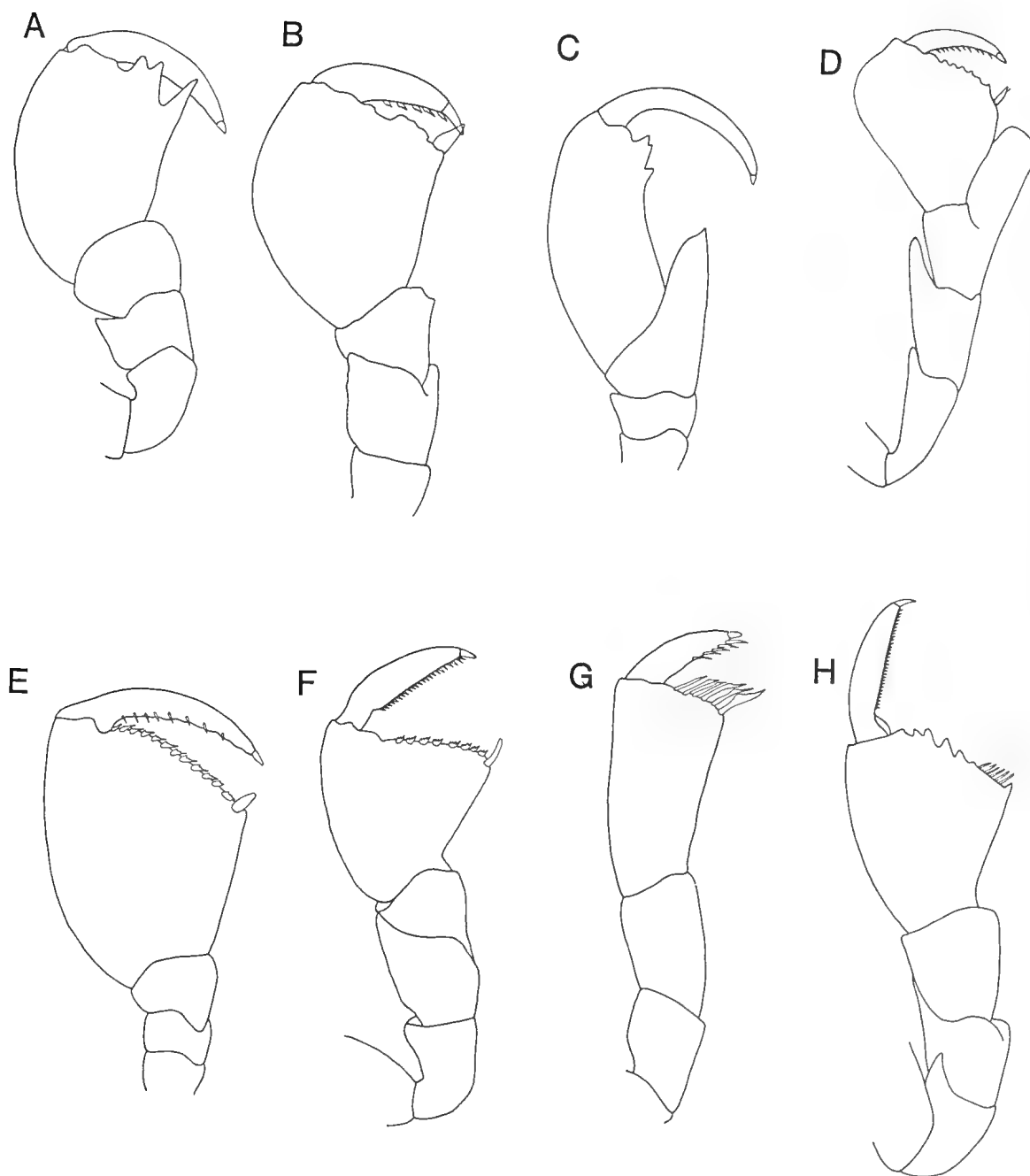


Fig. 2. Stenetriid genera showing body form and male pleopod II. A,B, *Mizothernar* n.gen. (after Kensley, 1984a, figs 33a, 34b). C,D, *Protallocoxa* Schultz (after Wolff, 1962, figs 1a, 5b). E,F, *Stenobermuda* Schultz (after Schultz, 1979b, figs 1, 3). G,H, *Tenupedunculus* Schultz (after Schultz, 1982, fig. 20a,c).

in *Stenetrium serraticaudum* Kussakin & Vasina, 1984) to no coxal projections (e.g., *Protallocoxa* and *Stenobermuda*).

Female Genitalia (Figs 13C,D, 26D,E). The external copulatory structure of *Stenetrium dagama* consists of an external cuticular pocket or broad groove on the anteromedial edge of pereonite 5. The groove possesses a short funnel-like depression and the posteromedial opening of the spermathecal duct ("cuticular organ"). The spermathecal duct extends posteriorly to the posterior edge of the spermatheca, which passes to the ovary via the lumen of the oviduct. This structure differs from *Asellus* by being attached to the ventral cuticle and the spermathecal

duct. This stenetriid form is similar in many respects to that of the Pseudojaniridae (Wilson, 1986a; Poore & Just, 1990), with the exception that *Stenetrium dagama* and *Stenetrium armatum* (Fig. 13C,D) have only a shallow pocket, and the deep stylet receptacle of the Pseudojaniridae is lacking. The presence of a well-defined stylet receptacle in *Stenetrium adrianae* n.sp. (Fig. 26D,E) suggests a closer relationship between the stenetriids and the pseudojanirids. The presence or absence of a stylet-like appendix masculina and its accompanying stylet receptacle may be a useful defining character for stenetriid genera. Owing to the variability in shape and length of the male stylet (in those species that possess a needle-like tip), a cor-



**Fig. 3.** Male pereopod I variation among stenetriid genera. **A**, *Stenetrium* Haswell. **B**, *Tristenium* n.gen. (after Müller, 1991c, fig. 10). **C**, *Hansenium* n.gen. (after Kensley, 1984a, fig. 37b). **D**, *Liocoryphe* n.gen. (after Kensley, 1984a, fig. 32). **E**, *Mizothernar* n.gen. (after Kensley, 1984a, fig. 33h). **F**, *Protallocoxa* Schultz (after Wolff, 1962, fig. 4a). **G**, *Stenobermuda* Schultz (after Kensley, 1994, fig. 9a). **H**, *Tenupedunculus* Schultz (after Schultz, 1982, fig. 22a).

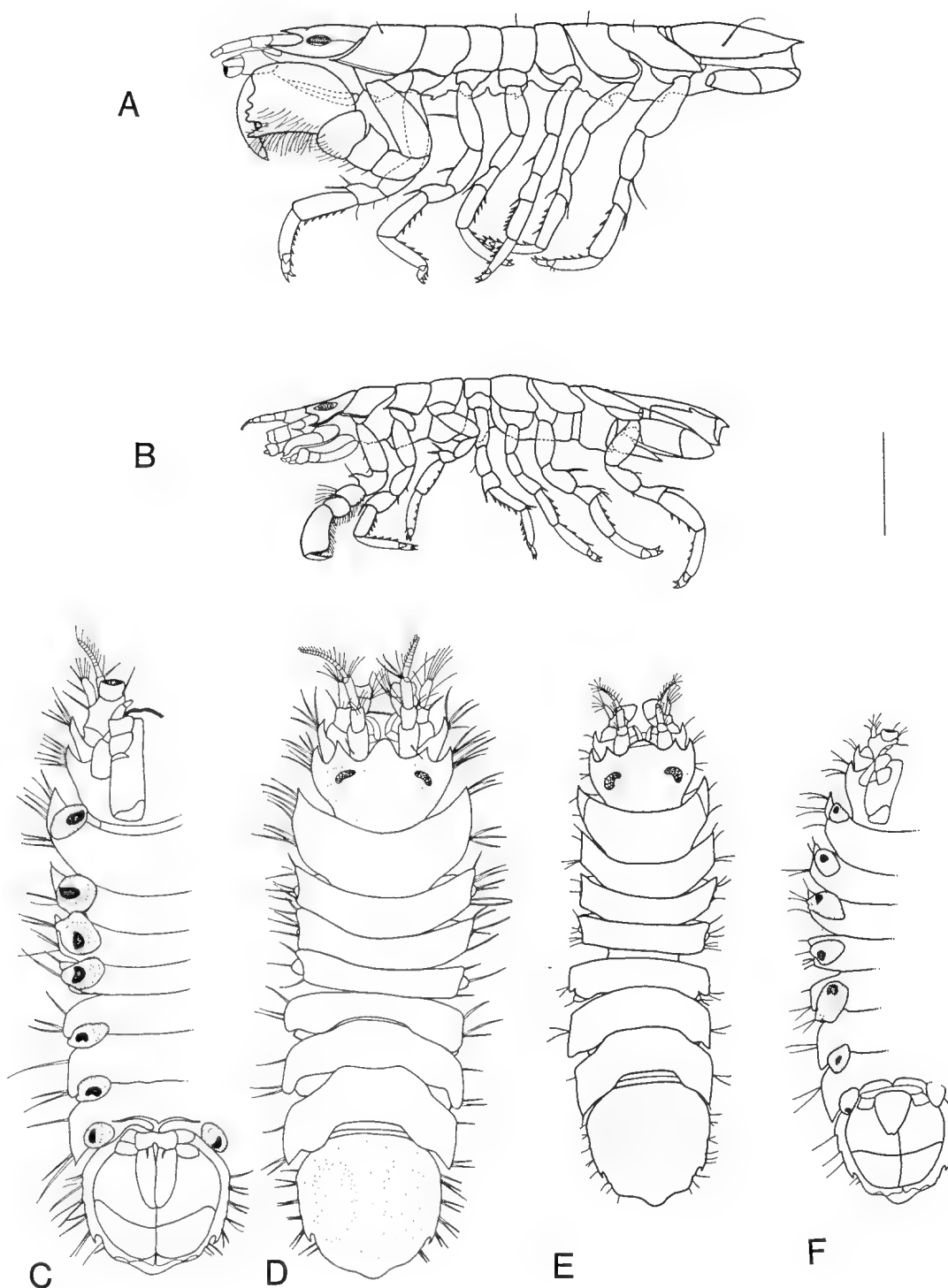


Fig. 4. *Stenetrium armatum* Haswell. A,C,D, neotype male (AM P.42112). B,E,F, female (AM P.3377). A,B, lateral view. C,F, ventral view. D,E, dorsal view. Scale bar = 1.0 mm.

responding species specific variability may be found in the female stylet receptacles. Generalisations concerning the stylet receptacle in the stenetriids must wait until many more species are inspected for this feature.

Pleotelson (Fig. 11, 24A). Three regions are diagnostic on the terminal segment of the body: the posterolateral spines, which are shared with the Gnathostenetroidoidea and the Pseudojaniroidea and some members of the Janiroidea; the telsonic region posterior to the spines may be evenly rounded or have various projections; and the lateral margins anterior to the spines that may be either smooth or serrate. These characters are reliable generic indicators.

Pleopods (Figs 11, 12, 13A,B, 25, 26A–C). The complex morphology of the pleopods, in particular, male pleopod II may be the most important, yet underused feature in the stenetriid classification. Hansen (1905) first proposed a division of the Asellota using the morphology of the pleopods and Wolff (1962) stated that the first and second male pleopods have offered excellent characters for distinguishing species.

The male pleopod I of the Stenetriidae is unique among the Asellota in having a large, rectangular sympod with two, unfused uniarticulated rami that are less than half the length of the pleotelson and are subequal in length to pleopod II. The rami are unornamented (i.e. do not have a stylet guide extension as is found in Pseudojaniroidea), but vary in shape and setation. This feature varies most at the species level.

The size of the fused sympod of the male first pleopod may be a useful dividing feature among some stenetriid taxa. In a majority of species, the sympod is large, rectangular and well illustrated, but in some species, such as those in *Tristenium* n.gen., in *Mizothernar* n.gen. and in *Stenobermuda*, the sympod is markedly reduced resulting in most authors neglecting to illustrate it. Schultz (1982) described the male pleopod I as without a fused sympod but questions whether it was absent or just not visible. In many of the above species, the sympod is present but reduced and is indicated in the illustrations by the proximal beginning of the sperm canal being above the connection of the pleopod to the sternum. This structure requires a detailed re-examination and may prove to be diagnostically significant.

The literature on asellotan relationships (Amar, 1957; Fresi *et al.*, 1980; Hessler *et al.*, 1979; Magniez, 1974; Wägele, 1983, 1989) suggests that the pleopods are homogeneous at the family level in the Stenetriidae. That this was not the case is apparent in our study of the male pleopod II, which was typically presented as having a blunt club-shaped appendix masculina. In fact, the stenetriid male pleopod II appendix masculina includes a broad variety of endopodal structures ranging from the blunt, club form to a stylet-like structure similar to that seen in the Janiroidea or some Aselloidea. Despite this great variety, a single theme emerges

from our study. The characteristic features of the stenetriid appendix masculina include a ventrolateral sperm groove on the appendix masculina that is proximally broad, with a median bowl-shaped sperm pocket. The sperm groove narrows distally with an overlapping distolateral margin, and with small distally directed cuticular hairs inside the groove. The appendix masculina of most species also have a subapical, lateral arc or ridge of anteriorly directed cuticular hairs or spines. These features are well demonstrated by the type species, *Stenetrium armatum*. Variation to the above form includes a solid, narrow, laterally-directed stylet having a row of fine denticles or barbs near the tip, as in *Stenetrium adrianae* n.sp. *Stenobermuda acutirostrata* and *Stenobermuda syzygus* have complex and uniquely shaped male pleopod II, although these may be modifications of the features described above.

The female pleopod II is typically triangular with or without an apical notch and varies in the shape of the lateral margins, the depth of the apical notch (when present) and setal arrangements on the lateral margins.

The remaining three sets of pleopods have been ignored in many classifications. In many instances, pleopod IV and the uniramous pleopod V have been left out completely. The diagnostic features of pleopods III–V morphology should be based on the length/width dimensions, shape, relative size to the other rami (when present) and setal arrangements. The most marked variation of these pleopods occurs in *Stenetrium patulipalma* and *Stenetrium maharepa* where pleopod IV exopod is shorter than the endopod and is styliform in shape. This pleopod appears to be an intermediate form between the Stenetriidae and the Gnathostenetroididae. Pseudojanirid pleopods II–V are almost identical to some Stenetriidae, again indicating a close relationship between the two families.

Uropoda (Figs 12F, 24B,C). The uropods are typically short and do not vary significantly throughout the Stenetriidae. They are best used as species-specific features and vary only in setal types and arrangements.

## Taxonomy

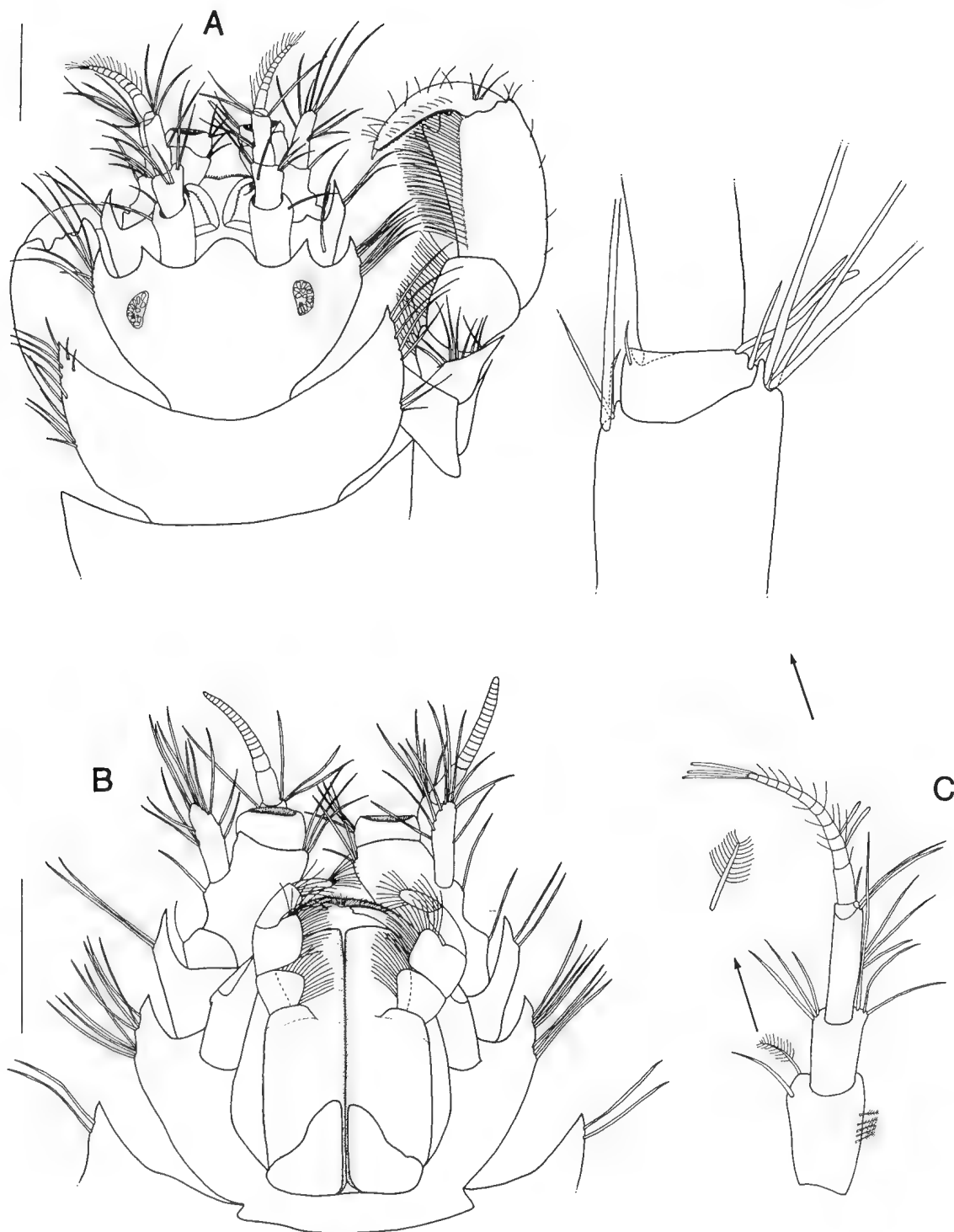
### Family Stenetriidae Hansen, 1905

Asellidae Sars, 1897: 95–96 (pars).

Stenetriidae Hansen, 1905: 315.

Stenetriidae.—Richardson, 1905: 439; Barnard, 1914: 216; Vanhöffen, 1914: 546; Wolff, 1962: 17–18, 21; Kensley, 1978: 144–149, fig. 65, 66; Schultz, 1982: 20; Kensley, 1989: 99.

**Family diagnosis.** Asellota with flattened body and subparallel lateral margins. Ventral surfaces of males with spine-like sternal keels (sometimes absent). Eyes



**Fig. 5.** *Stenetrium armatum* Haswell. Neotype male (AM P.42112). **A**, dorsal view of cephalon. **B**, ventral view of cephalon. **C**, antennula with enlargement of penicillate setae on article 1. **D**, antennular second flagellum remnant on article 3. Scale bar = 0.5 mm.

if present, dorsal. One or two free pleonites visible dorsally. Female spermathecal duct opens adjacent to oopore and posteriorly-directed pocket in ventral cuticle (stylet receptacle). Penes separate, emerging lateral to midline from posterior margin of pleonite 7 near medial side of coxa VII; penes tubular with non-overlapping rounded tips. Antennulae short, less than one-third body length. Antennal scale well developed, basally broad. Pereopod I sexually dimorphic, prehension between dactylus and propodus; propodus enlarged with strong comb setae (not bifid comb setae) on prehensile margin; carpus distinctly smaller than propodus, roughly trapezoidal. Pleopods I–II less than half length of pleotelson. Female pleopods II fused into single shield-like sympod, protopod absent. Male pleopod I with distinct protopod, fused medially; distal ramus clearly articulating with protopod; rami without distal stylet guides. Male pleopod II protopod with small apical, laterally-curving extension; exopod uniarticulate, short and broad, with oval transverse terminal hook; proximal endopodal segment tubular, elongate and narrow, shorter than distal segment; appendix masculina with distal groove or tube with many cuticular hairs terminating in laterally directed stylet or broad opening. Pleopod III endopod with 3 or more plumose setae. Uropods generally short but with protopod extending beyond posterior margin of pleotelson.

**Remarks.** Stylet-like appendices masculinae and “stylet receptacle-like” pockets near the female oopore are features seen also in the Pseudojaniridae, indicating a closer relationship between these two families than previously suspected (Wilson 1986a, 1987). Moreover, the blunt form of the appendix masculina is similar to that seen in the Gnathostenetroididae. Together, these three families may form an important clade within the Asellota.

### Generic level taxa of the Stenetriidae

At present, the Stenetriidae contains 62 described species and 5 genera, many of which are poorly defined. Our review of stenetriid species has identified 8 distinctive groupings, which we define below as genera. Existing and new genera are diagnosed below, and all genera are delineated with new synonymies. A revised species list with these groups is presented in Table 1. A few species cannot be placed in these genera (see Table 1) owing to incomplete descriptions. Within the group *Stenetrium* sensu stricto, much variability remains, with Australian examples illustrated by redescrptions of the type species, *Stenetrium armatum* Haswell, 1881, and *Stenetrium adrianae* new species.

### Key to the Genera of the Stenetriidae

1. Cephalon with sharply produced antennal and lateral spines and broad lateral lappets ..... 2
- Cephalon with lateral spines absent and antennal spines much reduced ..... 6
2. Cephalon with antennal and lateral spines subequal in length ..... 3
- Cephalon with antennal spines reduced and lateral spines extended ..... 4
3. Rostrum short, rounded to triangular; antennal and lateral spines subequal in length to the rostrum and each other; antennal article 1 with large lateral spine; male pereopod I propodus less than twice as long as propodal palm; carpus ventral margin not extended ..... *Stenetrium* Haswell, 1881.
- Rostrum short, apically flattened; male pereopod I with elongate dactylus twice as long as propodal palm; carpus ventral margin extended and serrate ..... *Hansenium* n.gen.
4. Rostrum short, round or truncated; pereonites lateral margin angular; male pleopod II appendix masculina elongate, narrow, distal tip rounded laterally and weakly pointed on medial margin; uropods large ..... *Tenupedunculus* Schultz, 1982.
- Rostrum elongate and pointed ..... 5

5. Rostrum robust with rounded distal tip; antennal spines almost absent; body robust; pereonites with rounded lateral margins; male pleopod II with blunt distal tip; pleotelson strawberry shaped; uropods barely emerging from posterior margin ..... *Protallocoxa* Schultz, 1978.
- Rostrum, narrow, sharply triangular with narrowly tapered point and longer than lateral spine; pereonites with sharply pointed anterolateral corners; male pleopod II appendix masculina elongate, with terminal cuticular fan; exopod positioned apically on protopod; female pleopod II rounded opercular shield ..... *Stenobermuda* Schultz, 1979a.
6. Rostrum triangular with broad base and narrow pointed tip; male pereopod I with broad robust propodus with denticulate setae and broad blunt teeth on palm; male pleopod II appendix masculina elongate, tapering to needlelike stylet with long setae on distolateral margin ..... *Tristenium* n.gen.
- Rostrum short, broad or bilobed; eyes reduced to small rounded group of ocelli ..... 7
7. Rostrum short, broad and rounded; cephalon smoothly rounded with antennal and lateral spines almost absent; Male pereopod I carpus lateral margin extended and blunt ..... *Liocoryphe* n.gen.
- Rostrum short, bilobed; pereopod I enlarged, as long as broad, larger than cephalon; pleotelson strawberry shaped with weak posterolateral spines ..... *Mizothernar* n.gen.

## Genera of the Stenetriidae

### *Stenetrium* Haswell, 1881 sensu stricto

Figs 4–26, 1A,B, 3A

*Stenetrium* Haswell, 1881: 479.

*Stenetrium*.—Chilton, 1884: 251; Bovallius, 1886: 4, 19–20; Beddard, 1886: 8; Stebbing, 1893: 379; Hansen, 1905: 316; Stebbing, 1905: 53–57; Nobili, 1906: 266; Richardson, 1910: 110; Barnard, 1914: 217; Vanhöffen, 1914: 546; Barnard, 1920: 398; Barnard, 1940: 430; Kensley, 1978: 144–149; Schultz, 1982: 20–21; Kensley, 1989: 99–100. *Jamna* Bovallius, 1886: 22–23.—Stebbing, 1893: 379; Richardson, 1910: 110.

Type species. *Stenetrium armatum* Haswell, 1881.

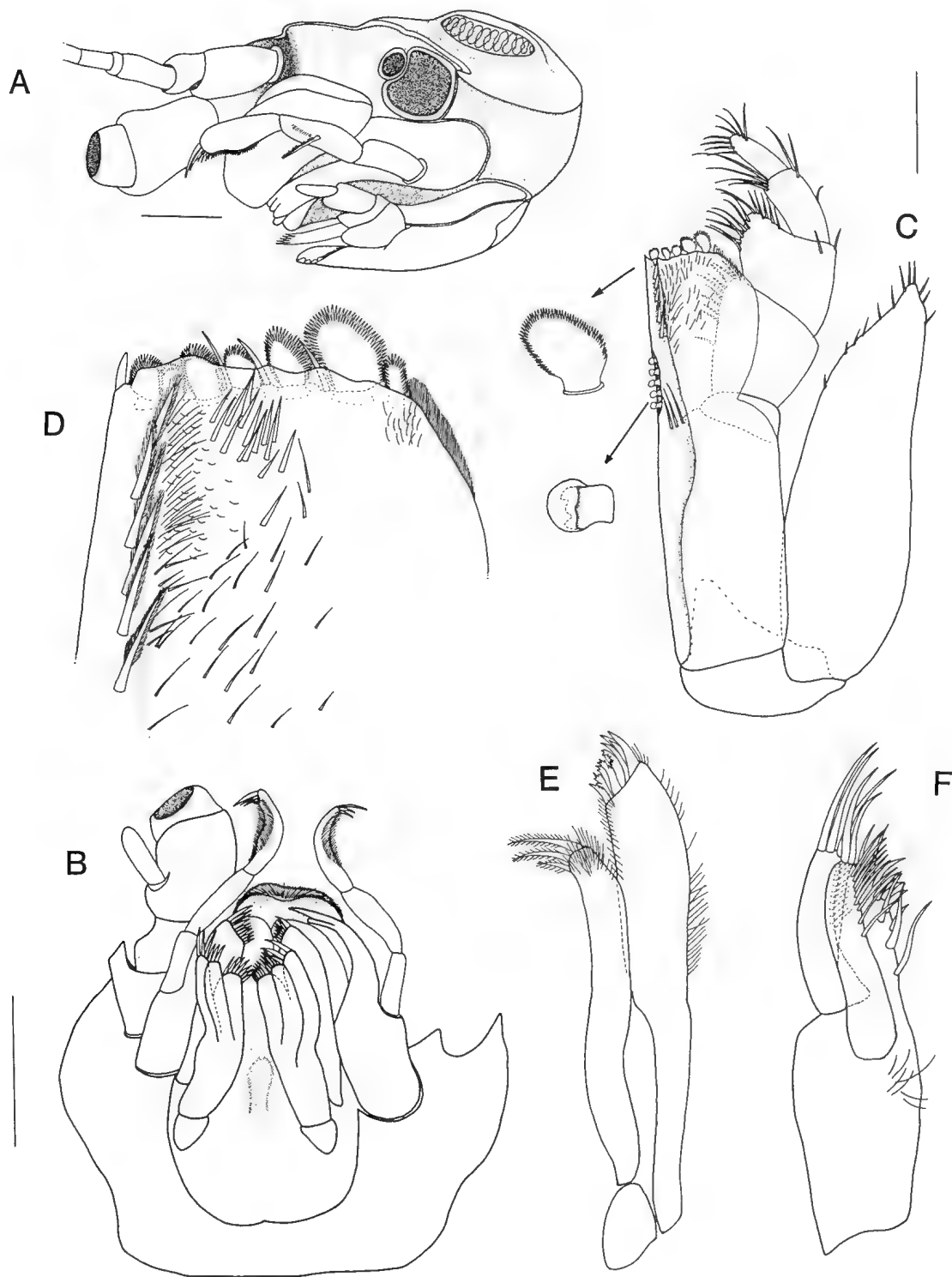
Species included. See Table 1.

**Diagnosis.** Head with large, reniform anterolateral eyes having about 18 ocelli; frontal margin with both prominent lateral and antennal spines; lateral spines generally extending past antennal spines; rostrum shape variable, length subequal to length of lateral spine. Antennular

flagellum articles ranging from 10–20. Antennal article 1 with large, acutely pointed, lateral spine. Maxilliped endopodite distal margin with 6 fan setae. Body lateral margins angular with single-lobed coxal extensions visible in dorsal view; pereonite 1 longer than remaining pereonites. Pereopod I of males robust with blades or teeth on propodal palm and without denticulate setae or large terminal seta; dactylus equal or longer in length than propodal palm width. Pereopod II–VII merus with 2 large setae on anterior dorsal margin. Pleopod I evenly rounded on lateral margins. Pleopod II protopod distal tip subequal to length of exopod and sharply produced; endopod and exopod positioned on distomedial margin. Appendix masculina of pleopod II with needlelike stylet on distal tip. Pleotelson with 2 free pleonites. Pleotelson broad with prominent posterolateral spines, posterolateral and medial telsonic cuticular extensions.

**Remarks.** This revised description of *Stenetrium* reduces the composition of the genus. Owing to the substantial differences between the male pleopods II between *S. armatum* and *S. adrianae* n.sp., we suspect the genus may yet be further divided as the species are better illustrated. These two species, which are treated here, provide a baseline for further descriptions in the Stenetriidae.





**Fig. 6.** *Stenetrium armatum* Haswell. Neotype male (AM P.42112). **A**, lateral-oblique view of cephalon with antenna removed. **B**, ventral view of cephalon with maxillipeds removed. **C**, maxilliped, dorsal view, with enlargements of distal fan setae and coupling hook. **D**, endite, dorsal view. **E**, maxillula. **F**, maxilla. Scale bar = 0.5 mm.

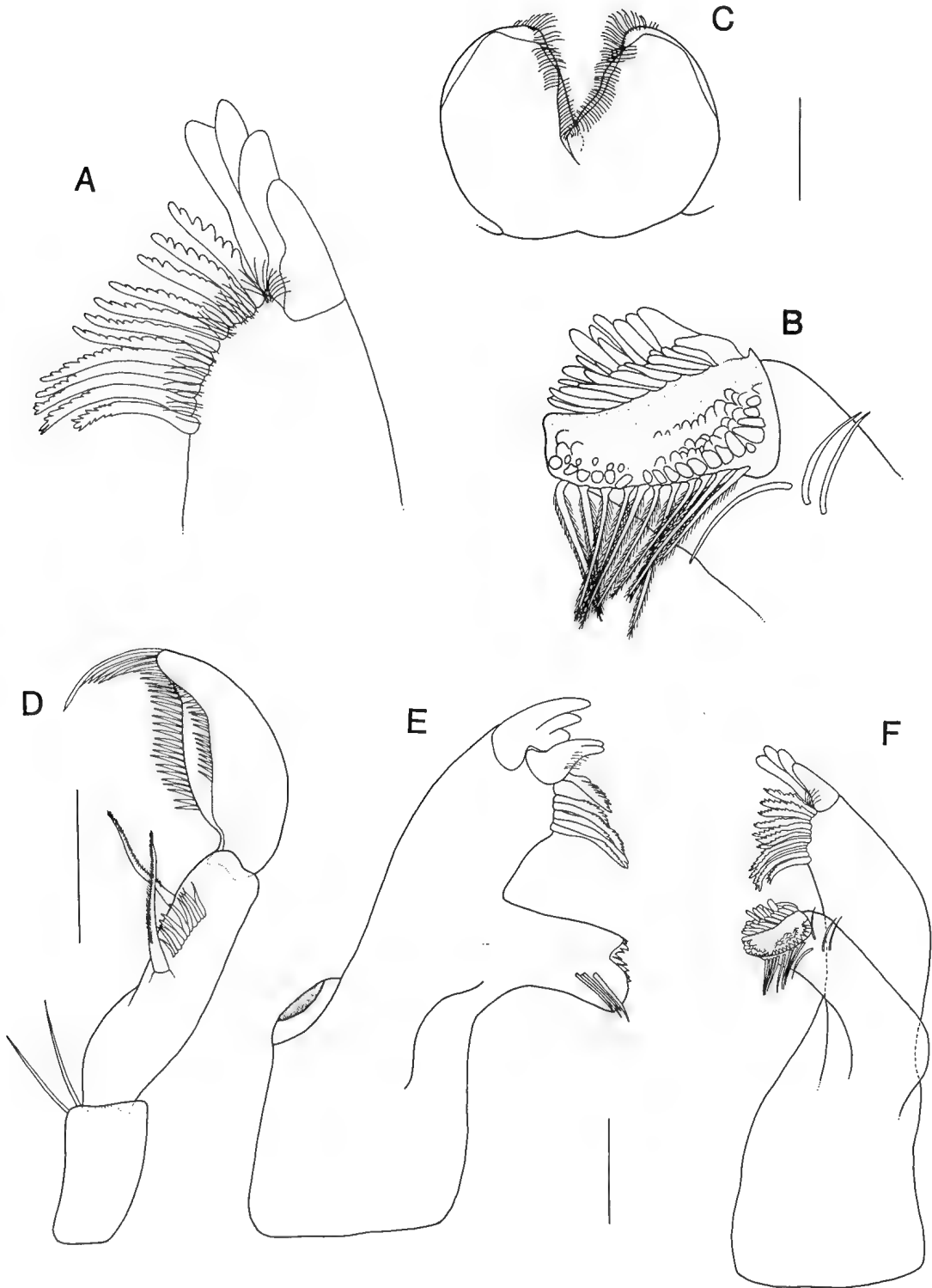


Fig. 7. *Stenetrium armatum* Haswell. Neotype male (AM P.42112). A, right incisor process, dorsal view. B, right molar process, dorsal view showing grinding surface. C, paragnath. D, mandibular palp. E, left mandible, dorsal view. F, right mandible, dorsal-oblique view. Scale bar = 0.1 mm.

*Stenetrium armatum* Haswell, 1881

## Description

Figs 4–13

*Stenetrium armatum* Haswell, 1881: 479, pl. 19, fig. 1.  
*Stenetrium armatum*.—Haswell, 1883: 308; Haswell, 1884: 1009–1010; Bovallius, 1886: 20–21; Hansen, 1905: 318, pl. 19, figs 1a–1d; Stebbing, 1905: 54; Nordenstam, 1946: 19; Wolff, 1962: 23; Schultz, 1982: 21–25, figs 2a–2j, 3a–3m, 4a–4e.  
*Stenetrium armatum*(?).—Hale, 1929: 324–325, 328.

**Types species.** *Stenetrium armatum* Haswell, 1881.

**Material examined.** Haswell (1881) did not designate a type series (Schultz, 1982; Springthorpe & Lowry, 1994). Therefore, we establish one specimen at the Australian Museum as neotype of this species and genus. NEOTYPE Australian Museum (AM) P42112, (one of 6 “possible syntypes”, original number AM P3377; see Springthorpe & Lowry, 1994), male, body length 5.25 mm, New South Wales: Port Jackson, Sydney (33°51'S, 151°16'E) “among algae a few feet below the low water mark” (Haswell, 1881: 479). Other material from type locality: AM P3377, remaining “possible syntypes”, 2 ovigerous females, 1 female, 2 males.

**Diagnosis.** Cephalon with anterolateral and frontal projection lengths subequal to rostrum length; antennal insertions closely spaced laterally with broad interantennular space. Pereon with sternal keels in males anteriorly directed on pereonites 1–4 and posteriorly on 6–7. Antennula as long as width of cephalon; male antennula with 16 articles. Coxal lobes visible in dorsal view on lateral margins of pereonites 2–5 in males and 3–5 in females. Pleotelson with weakly notched lateral margins. Mandibular incisor process with 4 distinct cusps; left spine row with 6 members. Male pereopod I with dactylus longer than width of propodal palm; propodal palm of males with 1 large terminating tooth, 2 connected medial teeth and 1 small, round proximal tooth; carpus length shorter than width in males. Female pereopod I dactylus ventral margin with up to 14 denticulate setae; ischium with prominent spine on anterodorsal corner. Male pleopod I protopod with 1 distal robust seta on each side of medial depression, rami of male narrow, evenly rounded on lateral margins; male pleopod II protopod distal tip sharply produced, appendix masculina with dorsal groove open posteriorly with spine-fringed dome on lateral side of groove. Female pleopod II with apical notch. Uropodal endopod with 3 transverse rings of sensillate setae, 2 distal penicillate setae and apical setal tufts shorter than endopod and exopod.

**Body** (Fig. 4). Adult male body length 5.25 mm (5.25–5.71 mm) and width 1.78 mm (1.78–1.85 mm) across widest point. Preparatory female body length 4.18 mm (3.52–4.18 mm) and width 1.18 mm (1.15–1.18 mm). Brooding female body length 5.03 mm (4.85–5.21 mm) and width 1.48 mm (1.43–1.53 mm). Length to width ratios 0.33, 0.28, 0.3 for male, preparatory female and brooding female respectively.

**Head** (Figs 5A,B, 6A,B). Large lateral spines and smaller antennal spines subequal in length to rostrum, medial length 0.6 width, 1.15 height. Cephalon freely articulated with pereonite 1. Eyes anterolateral, reniform with up to 18 ocelli depending on stage of development. Rostrum broadly rounded, margin denticulate or smooth, not sexually dimorphic. Dorsal surface medially convex with anterolateral flattened projections. Antennal insertions closely spaced laterally. Frons concave. Labrum evenly rounded, as long as broad, with fine setae fringing the anterior edge. Labrum projects 0.05 body lengths past the rostrum. Clypeus rounded, length 0.125 width, as broad as space between antennal insertions.

**Pereon** (Fig. 4). Pereonite 1 laterally longer than pereonite 2–7. Pereonite 5 shortest laterally. Dorsal surface sparsely setose, most dense at lateral margins; coxae positions and pereopodal insertions positioned anteriorly on pereonites 1–2, medially on pereonites 3–4 and posteriorly on pereonites 5–7. Sternal keel present in males as anteriorly directed spines on pereonites 1–4 and posteriorly directed spines on pereonites 6–7, pereonite 5 lacking spines. Single coxae visible in dorsal view along lateral edges of pereonites 2–5 in males, 4–5 in females.

**Pleon** (Figs 4, 11). Two free somites. Pleotelson length 1.07 width; length 0.26 body length; lateral margins weakly notched, with 2 elongate simple setae projecting posteriorly from each notch; posterolateral posteriorly directed spine 0.66 along length of pleotelson; small denticle posterior to spine; broadly rounded telson with rounded posterolateral margin. Pleotelson dorsal surface sparsely setose, with rounded longitudinal medial ridge with broad mildly convex lateral fields to each side.

**Antennula** (Figs 5C,D). Slightly shorter than cephalon width, length 0.36 body length. Male antennula with 16 articles, 13 articles in flagellum with one aesthetasc per article distally; 2 aesthetascs on final article. Article 1 length 1.2 width. One large penicillate seta on lateral margin and a row of 5 small penicillate setae on medial margin. Article 2 length 1.43 width with 2 distal groups of three simple setae. Article 3 medial length 3.7 width, with 2 groups of 3 simple setae. Remnant of second flagellum poorly defined on mediodistal side of article 3, with 2 projecting simple setae and one aesthetasc anterior to scale.

**Antenna** (Figs 5A,B). In neotype, only peduncular articles present. Articles 1 with large lateral spine extending almost to the anterior edge of article 2; medial



Fig. 8. *Stenetrium armatum* Haswell. Female (AM P.3377). A, dactylus and propodal palm, female pereopod I, with enlargements of 2 denticulate setae from dactylus and 1 denticulate setae from propodal palm. B, pereopod I, female with enlargement of plumose setae from propodal lateral margin. C, neotype male (AM P.42112), pereopod I, dactylus and propodal palm. D, enlargement of dactylus distal tip with enlarged bilobed setae. E, male pereopod I. Scale bar = 0.1 mm.

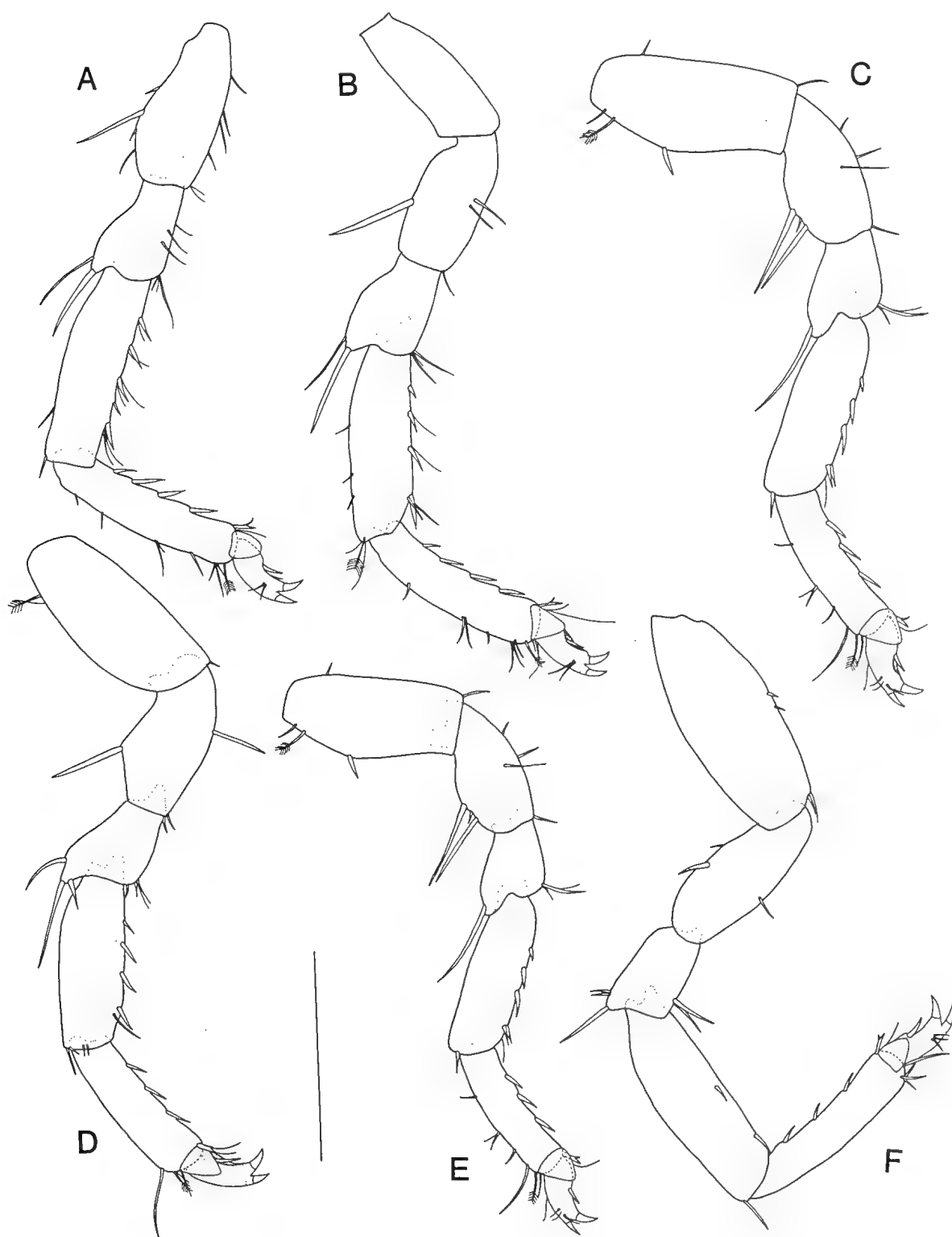
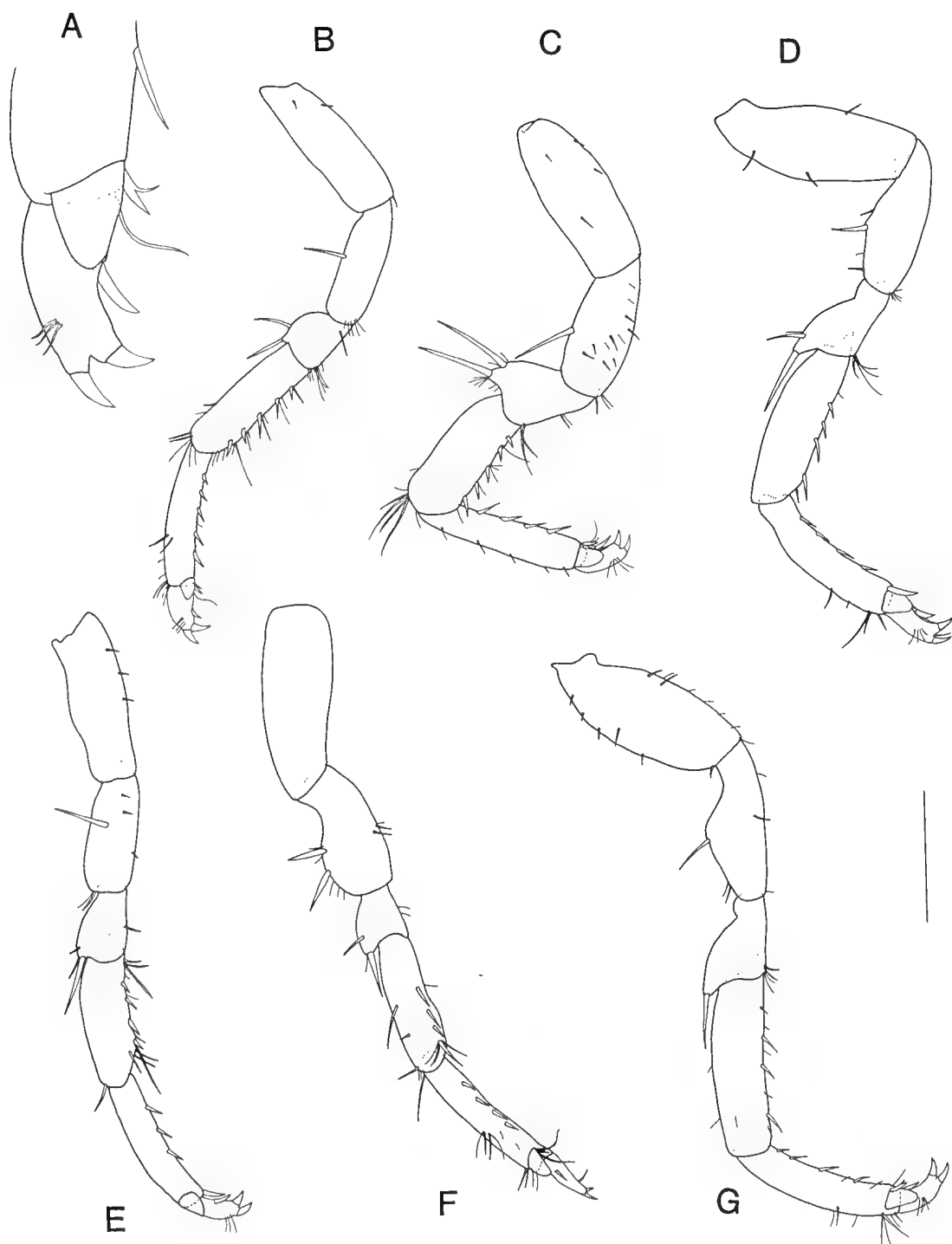


Fig. 9. *Stenetrium armatum* Haswell. Female (AM P.3377). A-F, pereopods II-VII. Scale bar = 0.5 mm.



**Fig. 10.** *Stenetrium armatum* Haswell. Neotype male (AM P.42112). A, dactylus, pereopod II. B–G, pereopods II–VII. Scale bar = 0.5 mm.

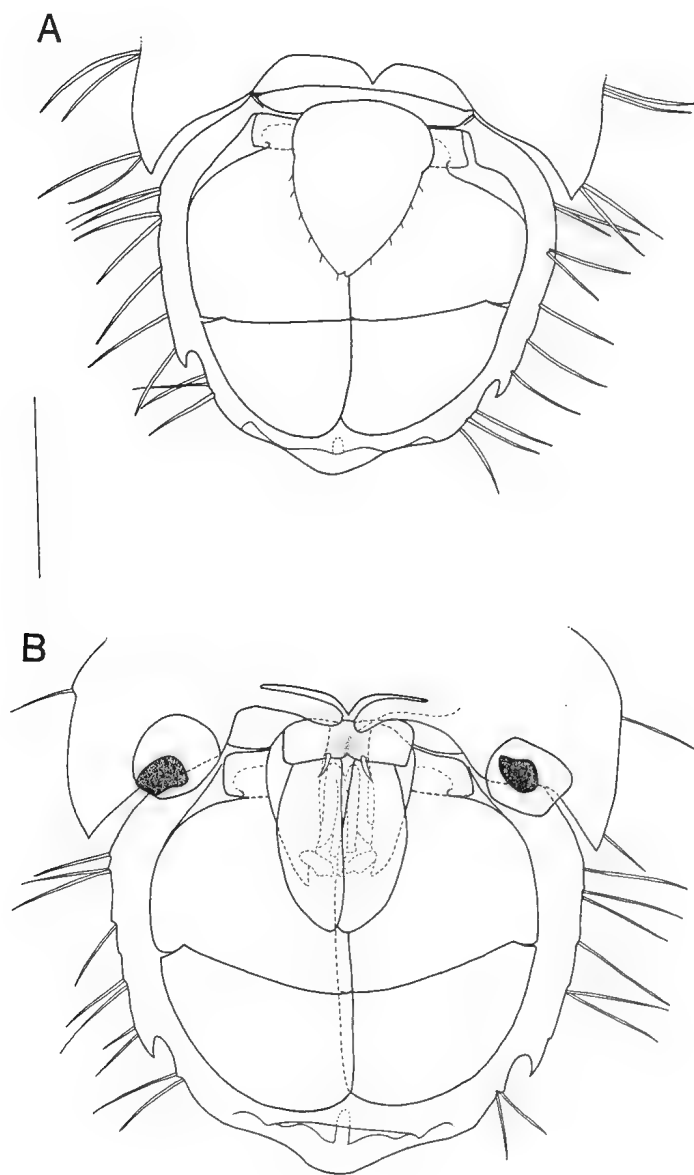


Fig. 11. *Stenotrium armatum* Haswell. A, female (AM P.3377), female pleotelson, ventral view. B, neotype (AM P.42112), male pleotelson, ventral view. Scale bar = 0.5 mm.

length 0.8 width. Article 2 with medial length 0.73 width; article 3 medial length 1.4 width.

**Mandible** (Figs 7A,B,D–F). Length 0.16 body length, with 4 distinct cusps on both incisor processes. Lacinia mobilis with 5 distinct cusps, 5 denticles on dorsal edge and several fine hair-like setae on basal ventral side. Left spine row with 6 members; first spine separate and attached to the base of the lacinia mobilis. Right spine row with 12 members having fine setae along the bases. Molar process length 0.23 length of mandibular body, stout with numerous pointed denticles around the pos-

terior lateral margin, 11 large penicillate setae and 3 simple setae below posterior margin, and numerous overlapping lamellar scales above anterior margin; triturating surface grading from coarse to fine granular denticles. Dorsal condyle smoothly rounded, length 0.2 length of mandibular body. Palp positioned 0.37 mandibular body length from posterior margin, length 0.62 length of mandibular body. Palp second article length 0.27 mandibular body length, with 2 large setae dorsally separated by distinct gap, each with fine setules along distal 3/4 of their length. Row of 11 small spinulose



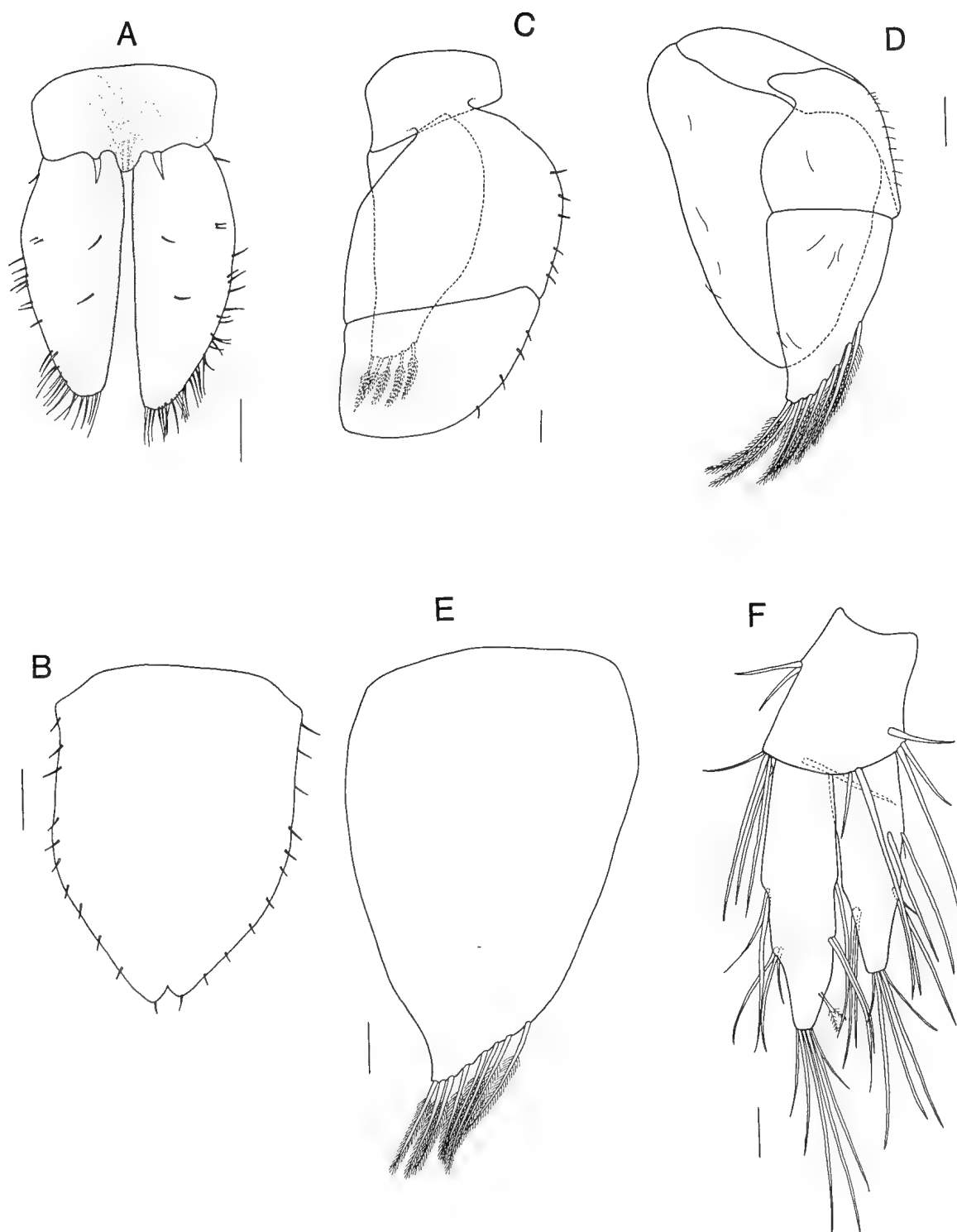
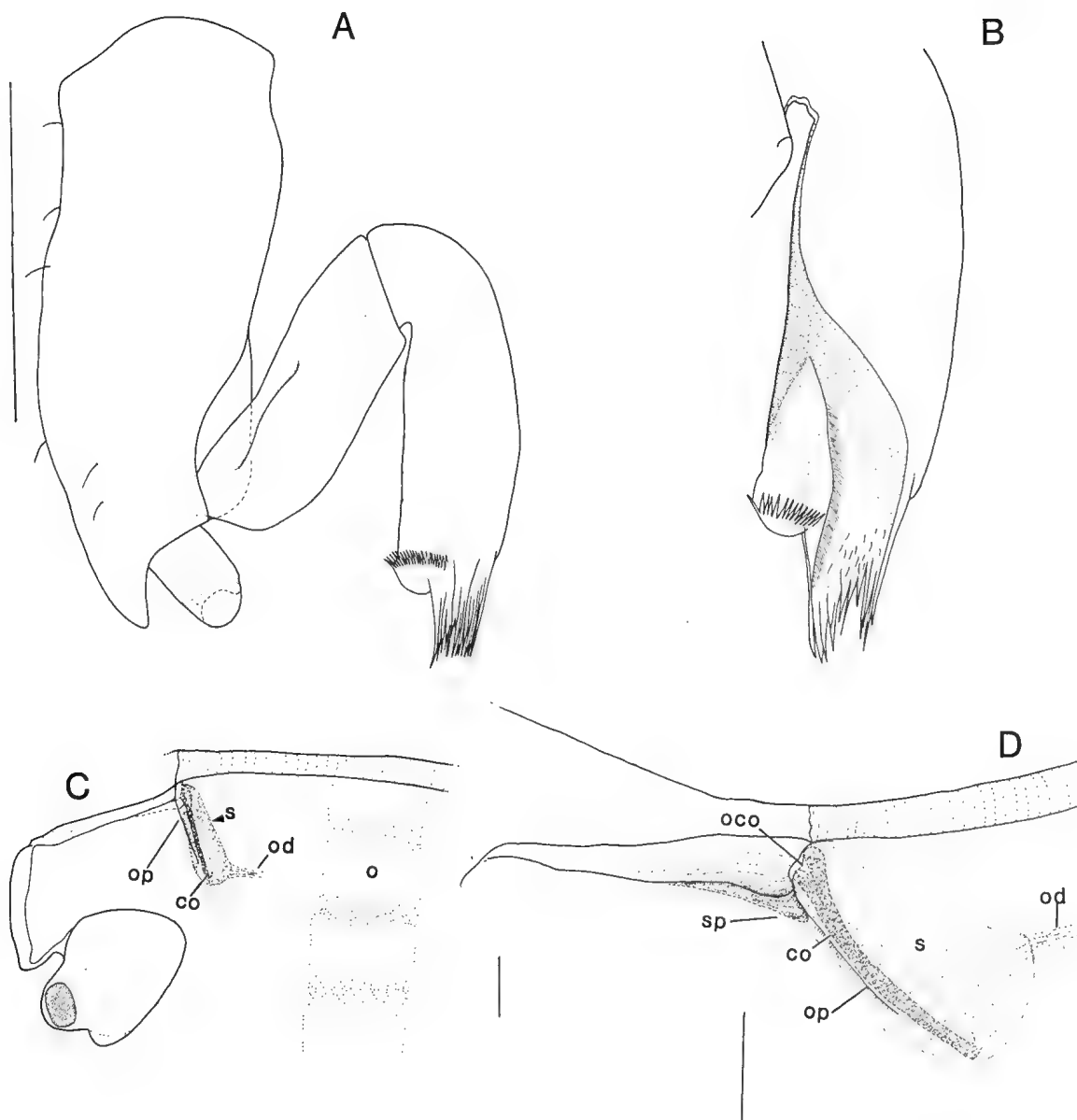


Fig. 12. *Stenetrium armatum* Haswell. A, neotype (AM P.42112), male pleopod I, ventral view. B, female (AM P.3377) female pleopod II, ventral view. Remaining pleopods of neotype (AM P.42112). C, pleopod III, ventral view. D, pleopod IV, ventral view. E, pleopod V, ventral view. F, uropod. Scale Bar = 0.1 mm.



**Fig. 13.** *Stenetrium armatum* Haswell. **A,B**, Neotype (AM P.42112). **A**, male pleopod II, ventral view. **B**, second endopod segment, male pleopod II, ventral view. **C,D**, preparatory female (AM P.3376), ventral view of pereonite V. **D**, enlargement of oopore (op) region through ventral cuticle showing oopore (op) with stylet pocket (sp) and opening to cuticular organ (oco), cuticular organ (co) attached to the base of spermatheca (s) adjacent to oviduct (od). Scale bar = 0.1 mm.

setae extending anteriorly between large setae. Article 3 with 2 rows of setae extending along 0.7 article length.

*Paragnath* (Fig. 7C). Anteriorly directed broadly rounded paired lobes, fused posteromedially; length 0.81 width; 2 rows of fine hair-like setae on distal and medial margins, each side single (not bilobed).

*Maxillula* (Fig. 6E). Lateral lobe with 9 robust spinose setae, anterior medial setae with posteriorly directed teeth and posterior setae with anteriorly directed teeth. Lateral lobe length 0.15 body length, medial lobe width 0.54 lateral lobe width, medial lobe length 0.83 lateral lobe length. Medial lobe with 3 large, densely setulate setae. Lobe margins and medial lobe distal end with fine hair-like setae.

*Maxilla* (Fig. 6F). Lobes slender. Lateral lobe with 3 large, denticulate setae on distal tip and 13 small, short, setae on medial margin. Middle lobe with 2 large, denticulate setae distally and 9 long setae on medial margin. Medial lobe distal surface and medial margin densely covered with spinose setae.

*Maxilliped* (Figs 6C,D). Basis elongate and robust, basal width 1.15 endite width. Endite with 5 coupling hooks, length 0.46 total basis length; distal tip with 7 robust fan setae and 3 spinose setae. Distomedial corner with one large, spine-like setae. Dorsomedial ridge of endite with 6 setulate setae. Palp article 2 width subequal to endite. Epipod elongate with sharp distal tip, length 3.2 width. Distal margin with 12 small, equally spaced simple setae.

*Pereopod I* (Figs 8A–E). Subchelate, sexually dimorphic, males larger with bladed extensions of propodal palm; total length 0.8 body length in males and 0.45 in females.

Males: dactylus length 1.2 propodal width; ventral edge of dactylus with alternating long and short spinulose setae, short setae terminating in bifid denticles, single, broad unguis on distal tip with accessory seta; surface of dactylus sparsely covered in simple setae. Propodus robust, length 1.3 width, densely covered in long simple setae; palm with 1 large ventral tooth, 2 mediodistal teeth and single dorsal tooth. Carpus short, length 0.7 width, medial margin densely covered in simple setae. Merus, short, trapezoidal, with numerous setae, dorsal margin with rounded distal extensions. Ischium and basis length 1.3, 2.6 width, respectively. Basis length 0.23 total pereopod length.

Female: dactylus length 1.1 propodal palm width; ventral margin of dactylus with 10 denticulate setae; distal tip with single claw. Propodus elongate, length 1.7 width; palm with 9 comb setae and 5 long simple setae, terminating in 1 long, robust spinose seta; ventrolateral margin with numerous long, plumose and simple setae. Carpus length 1.2 width, with dense row of plumose setae on ventral margin. Merus as long as wide with prominent distal spine on dorsal margin; numerous simple setae along ventral margin. Ischium dorsal margin with large, robust spine. Basis length 3.4 width, length 0.3 total pereopod length.

*Pereopods II–VII* (Figs 9, 10). Female pereopods length 0.54, 0.49, 0.44, 0.46, 0.49, 0.53 body length,

respectively, and male pereopods length 0.48, 0.42, 0.41, 0.43, 0.46, 0.46 body length, respectively. Propodus with 4–5, 3–4 short sensillate setae on ventral margin of pereopods II–III, IV–VII, respectively; 1 penicillate and several small sensillate setae on dorsodistal tip; robust bidenticulate sensillate setae on ventral surface. Carpus of both sexes with 4–5, 2–3 robust sensillate setae on ventral surface of pereopods II–VI, VII, respectively; penicillate setae on dorsodistal corner. Merus short with dorsodistal corner extended with large setae on tip. Ischium with 1–2 large seta on dorsal surface.

*Female Genitalia* (Figs 13C,D). The female specimen was not treated with KOH because only 1 brooding female was in the collection. Female oopore is a broad, posteriorly directed groove on anterior ventromedial margin of pereonite 5. Spermathecal duct (cuticular organ) of brooding female opens externally at anterior of oopore, and anteromedially adjacent to a cuticular fold that continues posteriorly into a shallow depression or stylet pocket. Opening of spermathecal duct is surrounded by thickened wall that narrows as organ extends posteriorly. A short tube connects orifice to posterior edge of the spermatheca. Spermatheca is an unexpanded, thin-walled sac that is attached to ventral cuticle and spermathecal duct. Spermatheca extending postero-medially into ovary via a thin-walled, expandable oviduct.

*Penes* (Figs 11B). Length 4.2 width; tubular, tip rounded, inserting 0.13 body width from midline.

*Male Pleopod I* (Figs 11B, 12A). Length 0.5 pleotelson length; width 0.1 pleotelson length; protopod length 0.6 width, fused medially producing a central depression between rami with 1 robust seta on each side. Rami lateral margin evenly rounded with simple setae on distal and lateral margin. Pleopod I covering pleopod II; length of pleopod I 1.3 length of pleopod II.

*Male Pleopod II* (Figs 13A,B). Protopod longer than wide, length 2.8 width, with distal tip sharply produced. Exopod length 1.4 width; positioned distolaterally on protopod. Endopod inserting 0.77 protopod length on medial margin. Endopod length 1.2 protopod length; appendix masculina length 1.6 length of proximal segment. Proximal segment with groove length 0.42 proximal segment length. Appendix masculina groove on dorsal surface, extending from mid length to distal tip, groove fringed by long fine cuticular spines and posteriorly directed fine cuticular hairs. Domed ridge dorsal to groove with fringe of anteriorly directed short spines.

*Female Pleopod II* (Fig. 11A, 12B). Shield shaped, length 1.3 width, length 0.5 pleotelson length, distal tip notched, length of notch 0.1 pleopod II length; lobes asymmetrical; fine simple setae evenly spaced around lateral margins.

*Pleopod III* (Fig. 12C). Exopod opercular, obliquely divided into 2 segments; not sexually dimorphic; length 1.6 width; length 0.9 pleotelson length. Endopod single segment, length 1.6 width; length 0.6 exopod length; posteriorly truncated with 5 plumose setae on apex.

*Pleopod IV* (Fig. 12D). Exopod with 2 segments;

length 2.5 width, tip tapering with 8 plumose setae. Endopod unsegmented, length 1.05 width; no setae on distal tip.

*Pleopod V* (Fig. 12E). Uniramous, length 1.5 width, length 0.6 pleotelson length; posteriorly pointed with 8 large plumose setae.

*Uropods* (Fig. 12F). Length 0.1 body length, length 0.2 pleotelson length. Protopod length 1.0 width; sensillate setae on medial and distal margins. Exopod shorter than endopod, length 0.8 endopod length; exopod 1.4 protopod length; shaft with 3–4 transverse rows of sensillate setae and distal tip with tuft of fine elongate simple setae, setal length 0.9 exopod length. Endopod length 1.7 protopod length; with 4–5 transverse rows of sensillate setae; 2 penicillate setae subdistally; distal tip with tuft of thin elongate simple setae, setal length 0.8 endopod length.

**Remarks.** The specimens marked as possible syntypes, held by the Australian Museum, had an uncertain origin. This material could not be shown to the same used by Haswell in his original descriptions. Haswell (1881) did not designate types in his description nor did he label specimens as types (Springthorpe & Lowry, 1994). The specimens of this species from Port Jackson may be the original specimens but they could also have been collected after the date of publication by others such as Whitelegge, McCulloch or Hedley. Consequently the term 'possible syntype' was used by Springthorpe & Lowry (1994). Schultz (1982), the last revisor of this species did not designate them as types. *Stenetrium armatum*, however, is the type of its genus, so stability in the generic concept would be improved by establishing a name-bearing specimen for the species. Therefore, one male (AM P42112) is assigned to be the neotype for *S. armatum* from the "possible syntype" specimens. This specimen matches, as well as can be determined, Haswell's (1881) original description of the species.

*Stenetrium armatum* may be distinguished from other species of the genus by the armature of the large subchelate pereopod I and unique pleopodal structures. Male pereopod I possesses a distinct dactylus that extends past the propodal palm; the propodal palm has a large, elongate, terminal tooth followed by 3 smaller teeth, 2 of which are broadly joined at their bases. Pleopod I rami has short, robust setae at the base of each ramus. A unique appendix masculina of pleopod II has a subapical fringe of proximally directed, short setae around a lateral dome and a broad apical opening surrounded by long cuticular hairs. Large sternal spines are found on pereonites 1–4 and 6–7. The female can be distinguished by a large spur-like spine on the medial margin of the pereopod I ischium. The distolateral margin of pereonite 5 has a notch above the coxal lappets and no proximal notch on the distolateral margin of pereonite 6.

### *Stenetrium adrianae* n.sp.

Figs 14–26

**Material examined.** HOLOTYPE, AM P42283, male, 6.6 mm, Munganno Point, Two Fold Bay, New South Wales, (37°06'S, 149°56'E) on subtidal wharf pile among tunicates, collected by S.J. Keable, Australian Museum, 10 October 1984. PARATYPES: 2 males, 3 females, 5 ovigerous females, AM P35651, type locality, 10 October 1984; 5 males, 9 females, 7 ovigerous females, AM P35652, from type locality, 26 March 1985; 2 males, 1 female, 2 juveniles, AM P35652, type locality, 26 March 1985; 4 males, 4 females, 1 ovigerous female, AM P36161, type locality, collected by S.J. Keable and S. Perry, 19 December 1985.

**Etymology.** The species name 'adrianae' is dedicated to Adriana, the wife of the first author, for her continuous support and encouragement.

**Diagnosis.** Cephalon with anterolateral and antennal spines shorter than rostrum length, sternal keels in males anteriorly directed on pereonites 2–3 and posteriorly on pereonites 6–7; coxal spines visible in dorsal view on lateral margins of pereonites 4–5 in males and 3–6 in females. Pleotelson with weakly notched lateral margins. Antennula length half width of cephalon; male antennula with 9 articles. Mandibular incisor process with 4 distinct cusps and no denticles; left spine row of incisor process with 5 members. Maxilla lateral lobe with 7 short robust setae on medial margin. Maxilliped endite with 6 long spinulose setae on distal margin. Male pereopod I with dactylus same length as propodal palm width; propodal palm of pereopod I in males with small tooth on margin, 1 large sharply pointed tooth and 1 small rounded tooth adjacent to dactylus; carpus length equal to width in males; opposing margin of dactylus of female pereopod I with 16 denticulate setae. Pereopod II ischium with 3 large simple setae on dorsal margin. Male pleopod I broad rami subquadrangular with clipped corner on lateral distal margin. Male pleopod II protopod with broad base, truncated posteriorly with apex roundly produced; appendix masculina with posteromedial opening on lateral margin and long needle-like stylet, without setae or teeth. Female pleopod II without apical notch. Pleopod IV and V of both sexes with 7 and 9 plumose setae, respectively. Uropodal endopod with 2 rows of latitudinal sensillate setae and 6 distal penicillate setae, exopod and endopod with apical setal tufts almost twice as long as rami.

### Description

*Body* (Figs 14, 15). Adult male body length 6.2 mm (5.6–6.6 mm) and width 1.9 mm (1.8–2.0 mm) across widest point. Preparatory female body length 5.2 mm (4.6–6.5 mm) and width 1.7 mm (1.3–2.1 mm). Brooding female body length 5.6 mm (5.1–6.1 mm) and width 1.9 mm (1.5–2.4 mm). Length to width ratios 0.31, 0.32,

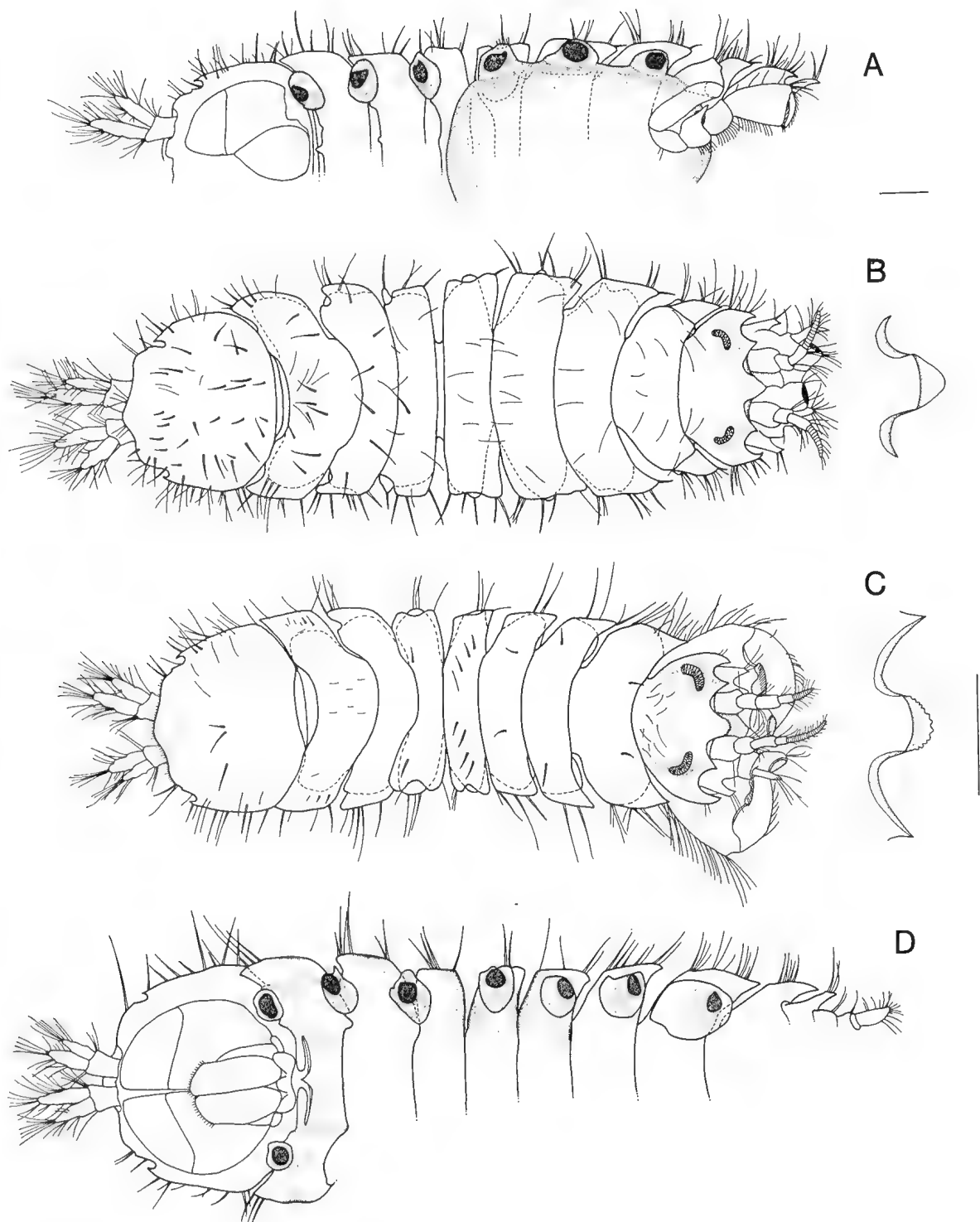
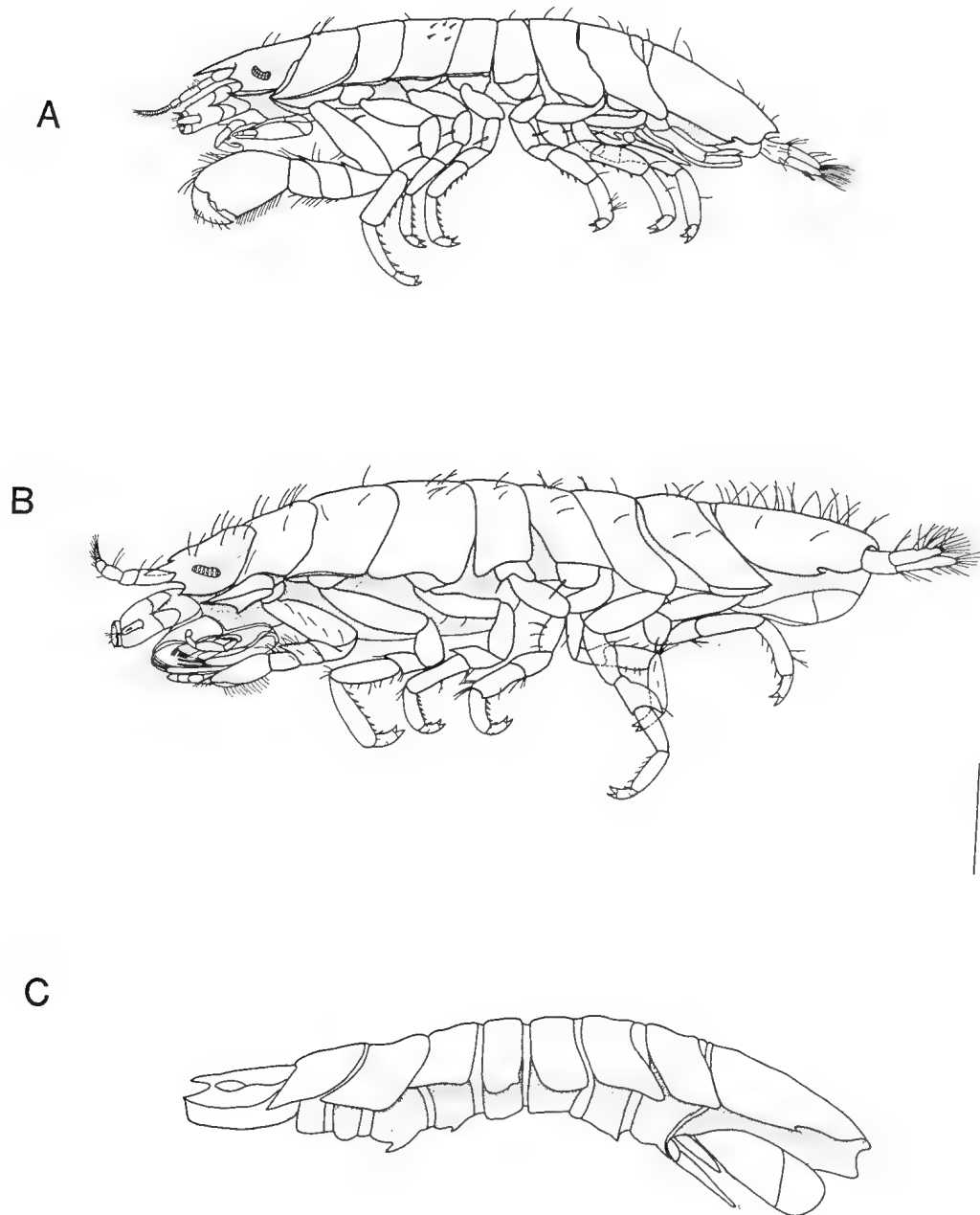


Fig. 14. *Stenetrium adrianae* n.sp. A, ventral view, paratype female (AM P.35651). B, body dorsal view with enlargement of rostrum, female (AM P.35651). C, body dorsal view, with enlargement of rostrum, holotype male (AM P.42283). D, body ventral view, male (AM P.42283). Scale bar = 0.5 mm.



**Fig. 15.** *Stenetrium adrianae* n.sp. A, body lateral view, holotype male (AM P.42283). B, body lateral view, paratype female (AM P.35651). C, body lateral view, showing sternal keel, holotype male. Scale bar = 1.0 mm.

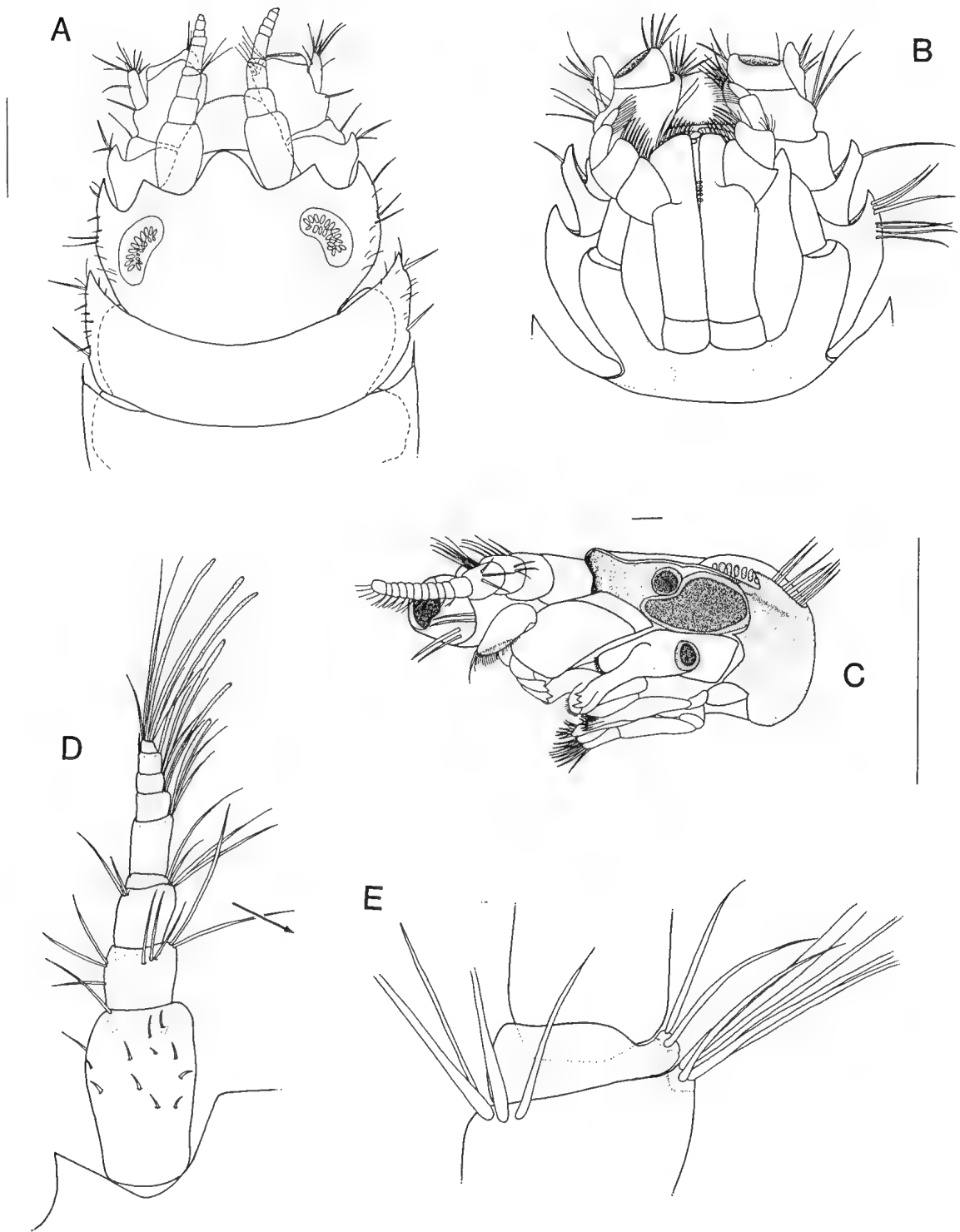


Fig. 16. *Stenetrium adrianae* n.sp. Holotype male (AM P.42283). A, cephalon, dorsal view. B, cephalon, ventral view. C, cephalon, lateral oblique view with maxillipeds removed. D, antennula. E, remnant flagellum on antennula article 3. Scale bar = 0.5 mm.



0.28 for males, preparatory females and brooding females respectively.

**Head** (Fig. 16A–C). Large anterolateral spines and smaller antennal spines shorter than length of rostrum. Cephalon dorsal length 0.6, 0.7 width females and males, respectively. Rostrum not sexually dimorphic, broadly rounded with either serrated or smooth tip. Eyes anterolateral, reniform with up to 20 ocelli. Labrum projects 0.15 cephalon lengths past the rostrum. Clypeus length 0.1 width, broader than space between antennule insertions.

**Pereon** (Figs 14, 15). Dorsal surface sparsely setose, most dense at lateral margins. Coxae and pereopodal insertions positioned anteriorly on pereonites 1–2, medially on pereonites 3–4 and posteriorly on pereonites 5–7. Single coxal spines visible in dorsal view on pereonites 4–5 in males and 3–6 in females. Pereonite 5 coxal spine medial in males and posterior in females. Sternal keel present in males as anteriorly directed spines on pereonites 2–3 and posteriorly directed spines on pereonites 6–7.

**Pleotelson** (Figs 14, 15, 24A). Length 1.0, 0.9 width, length 0.3, 0.3 body length in females and males respectively; lateral margins sparsely setose and smooth; prominent posterolateral spine. Pleotelson surface sparsely setose.

**Antennula** (Fig. 16D,E). Length 0.75 width of cephalon. Male antennula with 9 articles, 6 articles in flagellum with one aesthetasc per article; 2 aesthetascs on terminal article. Article 1 length 1.6 width, small spinose setae on distal half. Article 2 length 0.8 width with 3 groups of simple setae on both sides of distal margin. Article 3 medial length 1.05 width; 2 groups of 2 setae on medial and lateral distal margins. Second flagellum remnant poorly defined on medial side of article 3, with 2 projecting simple setae.

**Antenna** (Fig. 19A–C). Antenna length 0.83 body length. Article 1 medial length 1.2 width. Article 2 medial length 1.2 width; article 3 medial length 1.5 width. Prominent lateral spine on antennal article 1 extending anteriorly past articles 2 and 3 articulation.

**Mandible** (Figs 15A, 17B–F). Slender, length 0.66 cephalon length, with 4 distinct cusps on both incisor processes. Lacinia mobilis with 4 distinct cusps, no denticles on dorsal edge, several fine hair-like setae on proximomedial margin and six medially directed simple setae on dorsal base margin. Left spine row with 6 members; first spine separate and attached to base of lacinia mobilis. Right spine row with 12 members having fine setae along bases. Molar process length 0.27 mandibular body length; numerous pointed denticles around posterolateral margin; 9 large setose setae and simple setae below posterior margin; numerous overlapping lamellar setae on anterior margin. Triturating surface graded from coarse to fine granular denticles. Dorsal condyle smoothly rounded, length 0.2 mandibular body length. Palp equal in length to mandibular body length; palp second article length 0.4 mandibular body length, with 2 large setae positioned dorsodistally and mediodistally, with fine setation along upper 0.7 length. Row of 9 small spinose setae between large setae,

extending anteriorly from mediodorsal setae. Article 3 with 2 rows of setae extending 0.7 along article length.

**Paragnath** (Fig. 18B). Length 0.8 width; each side not bilobed; 2 rows of fine hair-like setae on distal and medial margins. Ventral surface with numerous cuticular combs.

**Maxillula** (Fig. 18D). Lateral lobe with 9 spinose robust setae, anteromedial setae with posteriorly directed teeth, posterior setae with anteriorly directed teeth. Lateral lobe length 0.52 cephalon length, medial lobe width 0.6 lateral lobe width, medial lobe length 0.8 lateral lobe length. Medial lobe with 3 large, densely setulate, setae and two small, short spinose setae. Medial and lateral lobe margins and medial lobe distal end with fine hair-like setae.

**Maxilla** (Fig. 18C). Lobes slender. Lateral lobe with 5 large setae on distal tip and 7 small, short, robust setae on medial margin. Middle lobe with 4 large setulate setae on distal tip and 7 long robust setae on medial margin. Medial lobe distal surface and medial margin densely covered with 13 robust, setulate setae.

**Maxilliped** (Fig. 19D–F). Basis width 1.1 endite width. Endite with 5 coupling hooks, endite length 0.4 total basis length; distal tip with 6 robust fan setae on ventral margin, increasing in size laterally to seta 5, with seta 6 reduced to 0.9 length of setae 5. Extremely fine hair-like setae along distal lateral margin and posterodorsal margin to fan setae 6. Six large spinose setae between fan setae on ventral surface and undulating cuticular ridge on dorsal surface. Medial distal corner with one large robust, spine-like setae. Dorsal medial ridge of basal endite with 5 setulate setae, and with extremely fine hair-like setae along bases of large setae, grading into spinose setae covering distomedial part of dorsal surface. Palp article 2 same width as endite. Epipod length 3.1 width, length subequal to basis length, distal margins with 12 small simple setae, length 1.6 basis length.

**Pereopod I** (Fig. 20). Subchelate, strongly sexually dimorphic, total length 0.7 body length in males and 0.4 in females. Strongly sexually dimorphic. Males: dactylus length subequal propodal width; opposing edge of dactylus with long and short simple setae; single claw on distal tip; surface of dactylus densely covered in long simple setae. Propodus robust, length 1.1 width, densely covered in long simple setae; palm with 1 small terminating tooth, one large, sharply pointed tooth and one smaller rounded tooth. Carpus length 0.9 width, ventral margin densely covered with simple setae. Merus length 1.4 width, trapezoidal, with numerous setae, dorsal margin sharply elongated distally. Ischium and basis length 1.4, 4.6 width, respectively. Basis length 0.32 total pereopod length. Female Pereopod I: dactylus length subequal to propodal palm width; opposing edge of dactylus with 16 denticulate setae, 4 long simple setae and single claw on distal tip. Propodus elongate, length 1.4 width; propodal palm with 11 comb setae, terminating in a long, robust seta; numerous long distally plumose setae and simple setae on ventral margin only. Carpus length 0.8 width, with dense row of distally plumose setae on distal part of ventral margin.

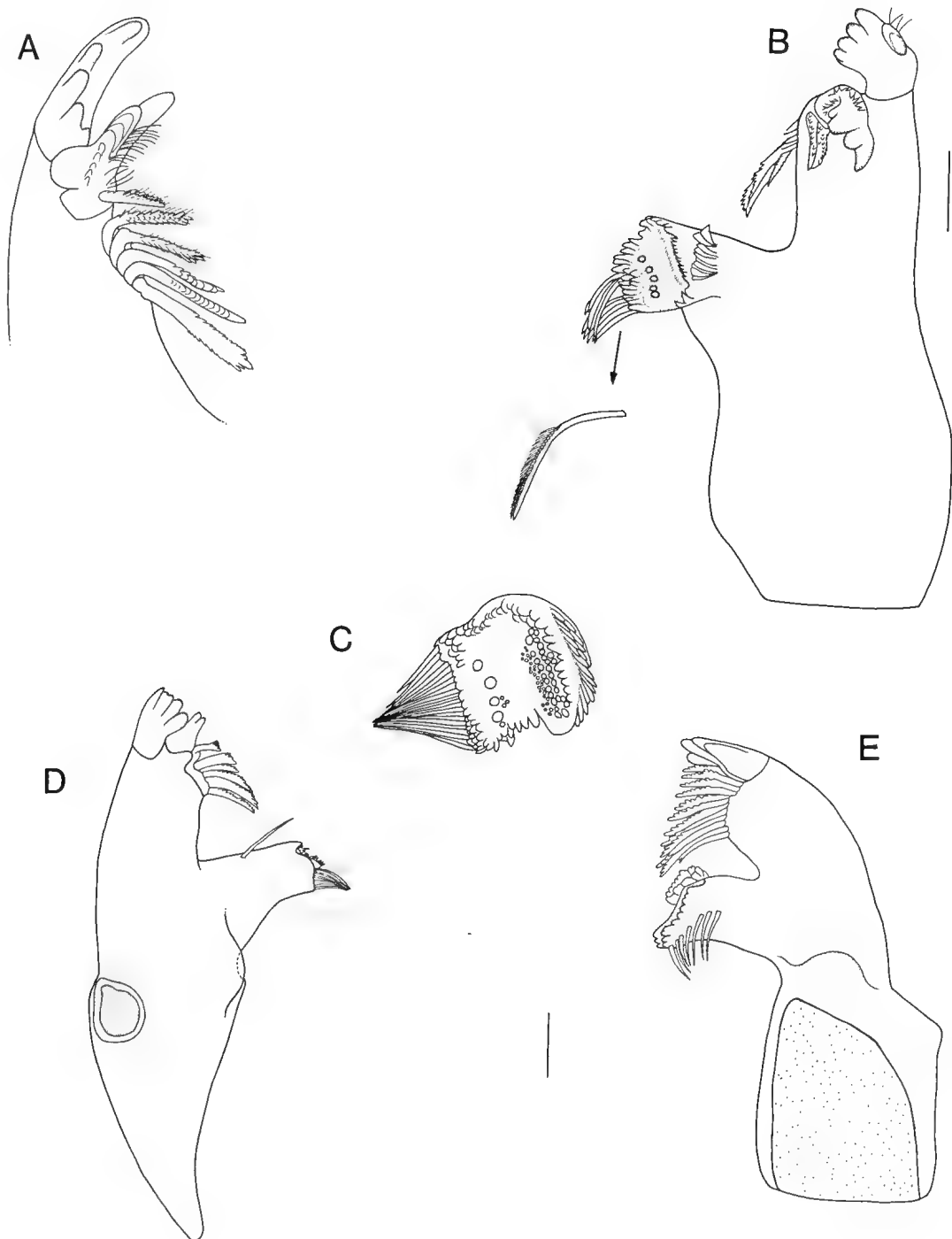
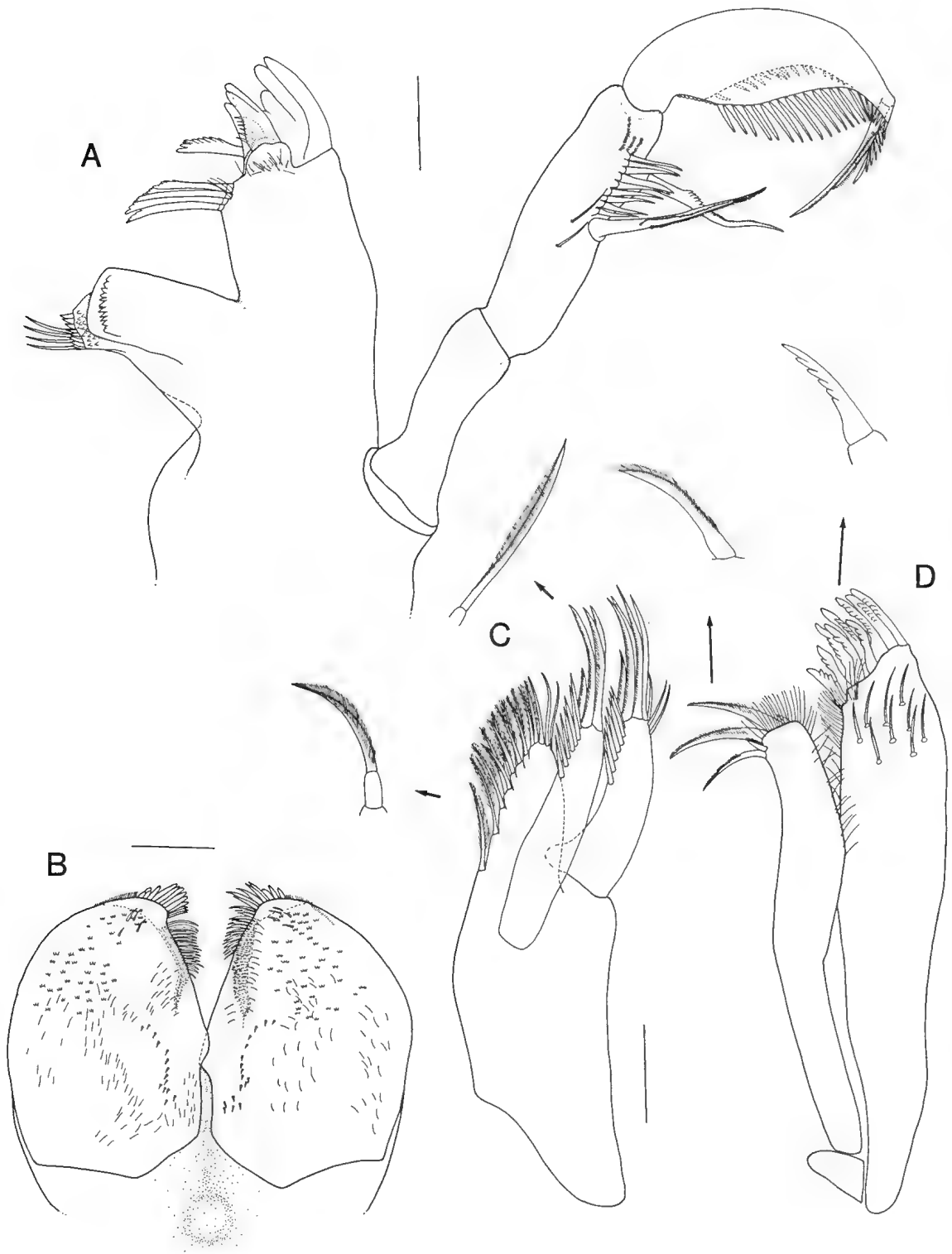


Fig. 17. *Stenetrium adrianae* n.sp. Holotype male (AM P.42283). A, left incisor process showing lacinia mobilis. B, left mandible with an enlargement of molar process setae. C, left mandible molar process grinding surface. D, left mandible showing condyle. E, right mandible showing condyle. Scale bar = 0.1 mm.



**Fig. 18.** *Stenetrium adrianae* n.sp. Holotype male (AM P.42283). A, left mandible with palp. B, paragnath. C, maxilla, with enlargement of 2 setal types. D, maxillula with enlargement of inner lobe setae and outer lobe denticulate setae. Scale bar = 0.1 mm.

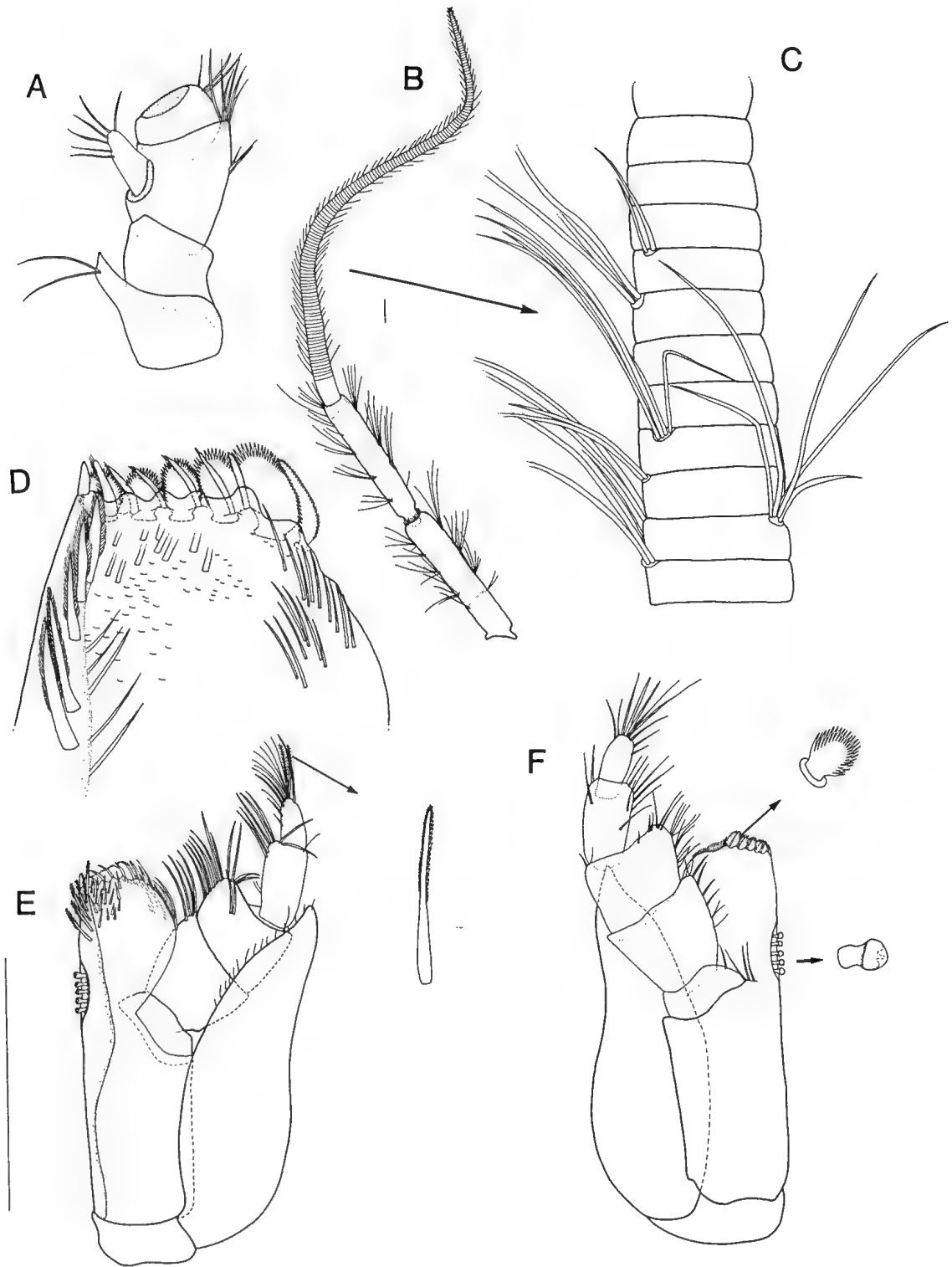
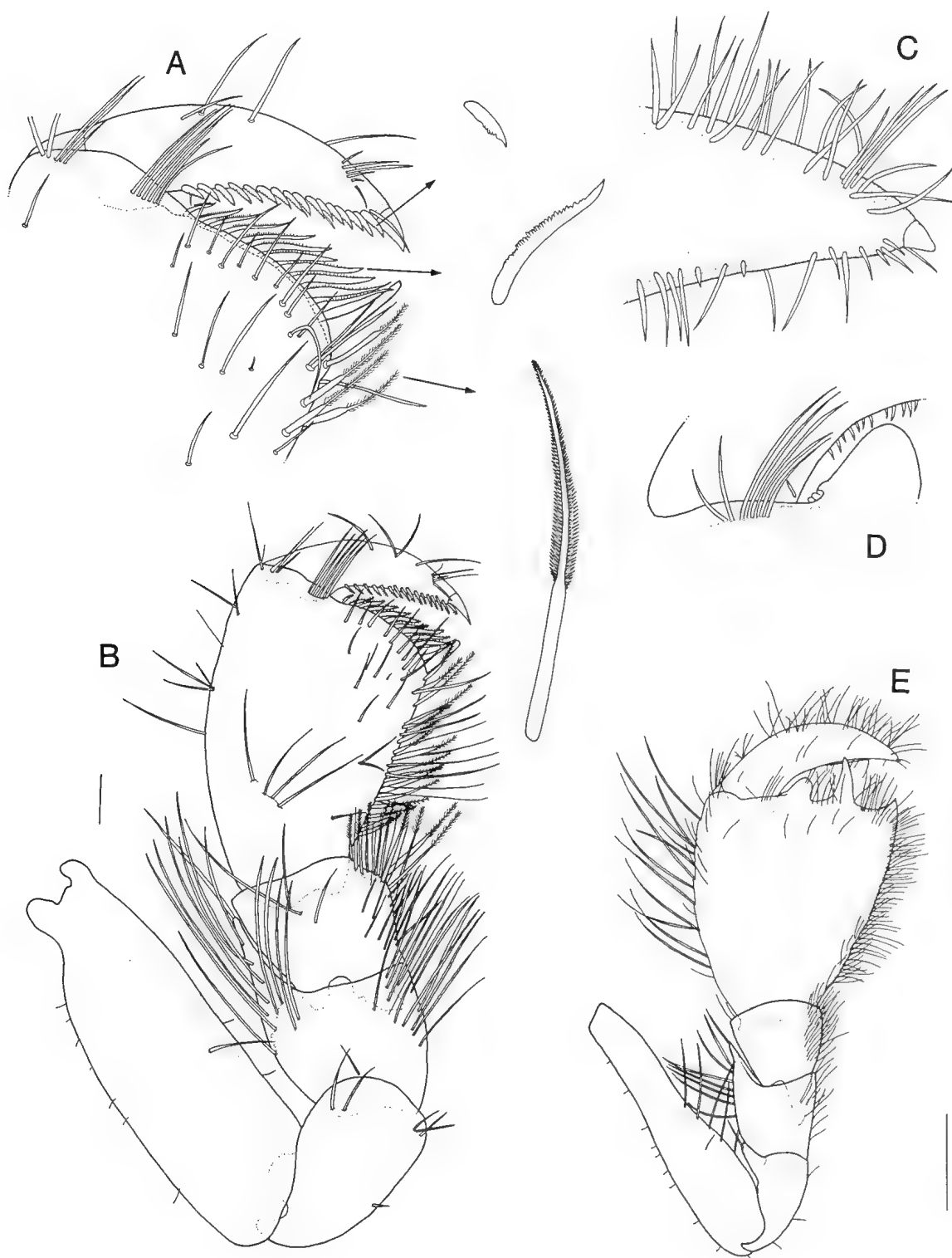


Fig. 19. *Stenetrium adrianae* n.sp. Holotype male (AM P.42283). A, antenna peduncular articles. B, antenna flagellum articles. C, antenna, close up of flagellum articles. D, maxilliped endite, dorsal view. E, maxilliped, dorsal view and enlargement of plumose setae on distal tip of palp. F, maxilliped, ventral view with enlargement of fan setae and coupling hook. Scale bar = 0.1 mm.



**Fig. 20.** *Stenetrium adrianae* n.sp. **A,B**, paratype female (AM P.35651). **A**, female pereopod I, dactylus and propodus with enlargement of denticulate setae and lateral plumose setae. **B**, female pereopod I. **C-E**, holotype male (AM P.42283). **C**, male dactylus, distal tip. **D**, male dactylus, proximal joint. **E**, male pereopod I. Scale bar = 0.1 mm.

Merus length 0.8 width, with prominent narrow distal extension of dorsal margin, almost parallel with lateral margin of carpus; medial and lateral margins with numerous long, simple setae. Ischium length 1.3 width. Basis length 2.9 width, length 0.31 total pereopod length.

*Pereopods II–VII* (Figs 21–23). Male similar to female but more setose. Female pereopods II–VII length 0.44, 0.37, 0.34, 0.36, 0.40, 0.43 body length, respectively, and male pereopods length 0.48, 0.44, 0.39, 0.41, 0.46, 0.47 body length, respectively. Dactylus anterodorsal surface has 3 sensillate setae; ventral surface has 2 sensillate setae between distal claws. Propodus of both sexes with 6, 5 short sensillate setae on ventral margin on pereopods II–III, IV–VII, respectively; 1 penicillate and several small sensillate setae on dorsodistal tip; robust bidenticulate sensillate setae and one long simple setae on ventral surface. Carpus with 5 (pereopod VII has 2) robust sensillate setae on ventral surface; penicillate setae on dorsodistal corner. Merus dorsodistal corner acutely extended with 2 large setae on tip of pereopods II–VII. Ischium with 1 long, robust seta on dorsal surface of pereopods II–VII. Male basis with 2, 3, 1, 0 simple setae on dorsal surface of pereopods II, III, IV–VI, VII, respectively.

*Female Genitalia* (Fig. 26D,E). The female specimen was treated with KOH in order to clear the cuticle and remove muscle tissue. Female oopore is a broad, posteriorly directed groove on anterior ventromedial margin of pereonite 5. Spermathecal duct (cuticular organ) of brooding female opens externally at anterior of oopore, and anteromedially adjacent to a cuticular fold that continues posteriorly into a blind sac or stylet receptacle. Opening of spermathecal duct surrounded by thickened wall that narrows as duct extends posteriorly. A short tube connects orifice to posterior edge of the spermatheca. Spermatheca is unexpanded, thin-walled sac that is attached to ventral cuticle and spermathecal duct. Spermatheca extends posteromedially into ovary via a thin-walled, expandable oviduct.

*Penes* (Fig. 24A). Length 4.25 width, tubular and posteromedial on pereonite 7.

*Male Pleopod I* (Fig. 25E). Length 0.51 pleotelson length; width 0.1 pleotelson length; protopod length 0.3 width. Rami subquadrangular with oblique corners on distolateral margin. Lateral margin with simple setae increasing in number posteriorly. Pleopod I extending over pleopod II completely, pleopod I length 1.1 length of pleopod II.

*Male Pleopod II* (Fig. 26A–C). Length 2.9 width. Protopod with broad base, pointed posteriorly with posterolateral corner rounded and produced with 5 simple setae on lateral margin. Exopod length 1.3 width. Endopod length 1.7 protopod length; appendix masculina length 2.3 proximal segment length. Proximal segment ventral groove length 0.5 proximal segment length; 5 sensillate setae on distoventral surface. Appendix masculina stylet-like with distal open groove on lateral side folding to closed tube distally; proximal groove with fine cuticular combs; distal tube thickened, rod-like, with

internal striations and external denticles on medial margin.

*Female Pleopod II* (Fig. 25A). Shield shaped, length 1.2 width, length 0.4 pleotelson length, anterior half subparallel, posterior half pointed; evenly spaced fine simple setae around lateral margins.

*Pleopod III* (Fig. 25B,F). Exopod length 2.0 width; length 0.8 pleotelson length; endopod length 1.8 width; length 0.8 exopod length; narrowing distally with 5 plumose setae on apex in females, 4 in males.

*Pleopod IV* (Fig. 25C,G). Exopod length 2.1 width, pointed posteriorly with 7 plumose setae. Endopod length 0.7 width.

*Pleopod V* (Fig. 25D,H). Uniramous, length 1.9 width, length 0.1 body length; posteriorly truncated with 9 large plumose setae.

*Uropods* (Fig. 24B,C). Length 0.04 body length, length 0.5 pleotelson length. Protopod length 0.6, 0.9 width in males and females respectively; medial and distal margins with large simple setae. Exopod length 1.2, 1.3 protopod length, endopod length 1.4, 1.7 protopod length, exopod length 0.9, 0.7 endopod length, in males and females respectively. Endopod with 3 latitudinal sensillate setal rows and 2 groups of 3 rows of subdistal penicillate setae.

**Remarks.** *Stenetrium adrianae* was originally identified as *S. armatum* in the collection of the Australian Museum. Although the two species are similar in body shape and dimensions, several morphological characters distinguish *S. adrianae* from the latter species: the male pereopod I dactylus is equal in length to the propodal palm width, not extended past the palm as in *S. armatum*; the propodal palm has a small terminal tooth followed by two large, distinctly separate teeth; large sternal spines are present only on pereonites 2–3 and 6–7; the appendix masculina of pleopods II in males terminates in a long needle-like stylet.

Females can also be distinguished among other species: pleopod II lacking an apical notch, the shape of distolateral corners of pereonites 5–6 (i.e. the shape, depth and position of the coxal spines and notches on the pereonites); the absence of large spur-like spines on the carpus, merus and ischium of pereopod I; the presence of a deep stylet receptacle, matching the elongate stylet of the male.

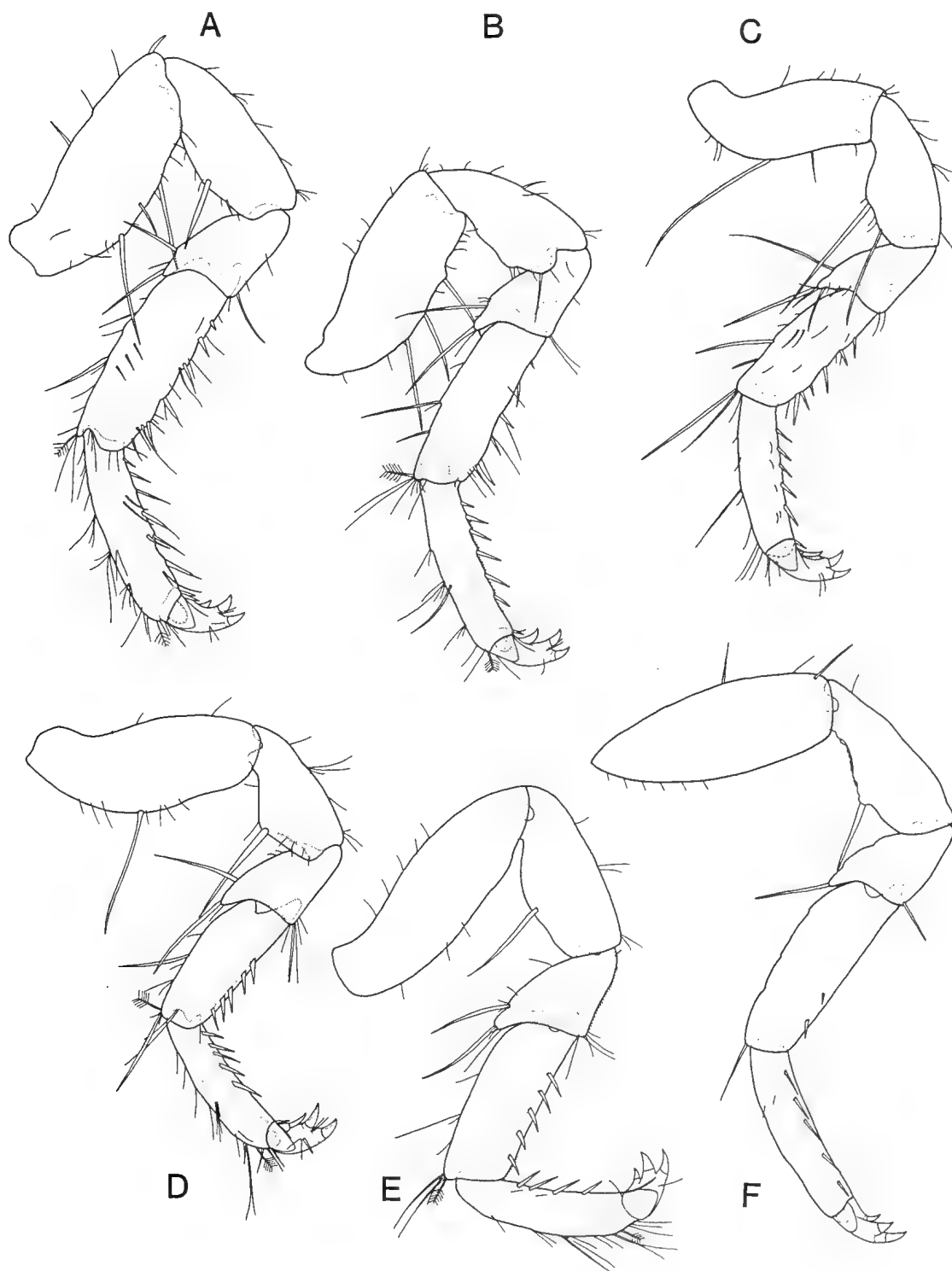
### *Tristenium* n.gen.

Figs 1C,D, 3B

**Type species.** *Tristenium acutirostrum* (Müller, 1991b).

**Species included.** See Table 1.

**Etymology.** *Tristenium* is a re-arrangement and modification of *Stenetrium*, and is similar to the name of the second author's son. The gender is neuter.



**Fig. 21.** *Stenetrium adrianae* n.sp. Holotype male (AM P42283). A-F, pereopods II-VII. Scale bar = 0.5 mm.



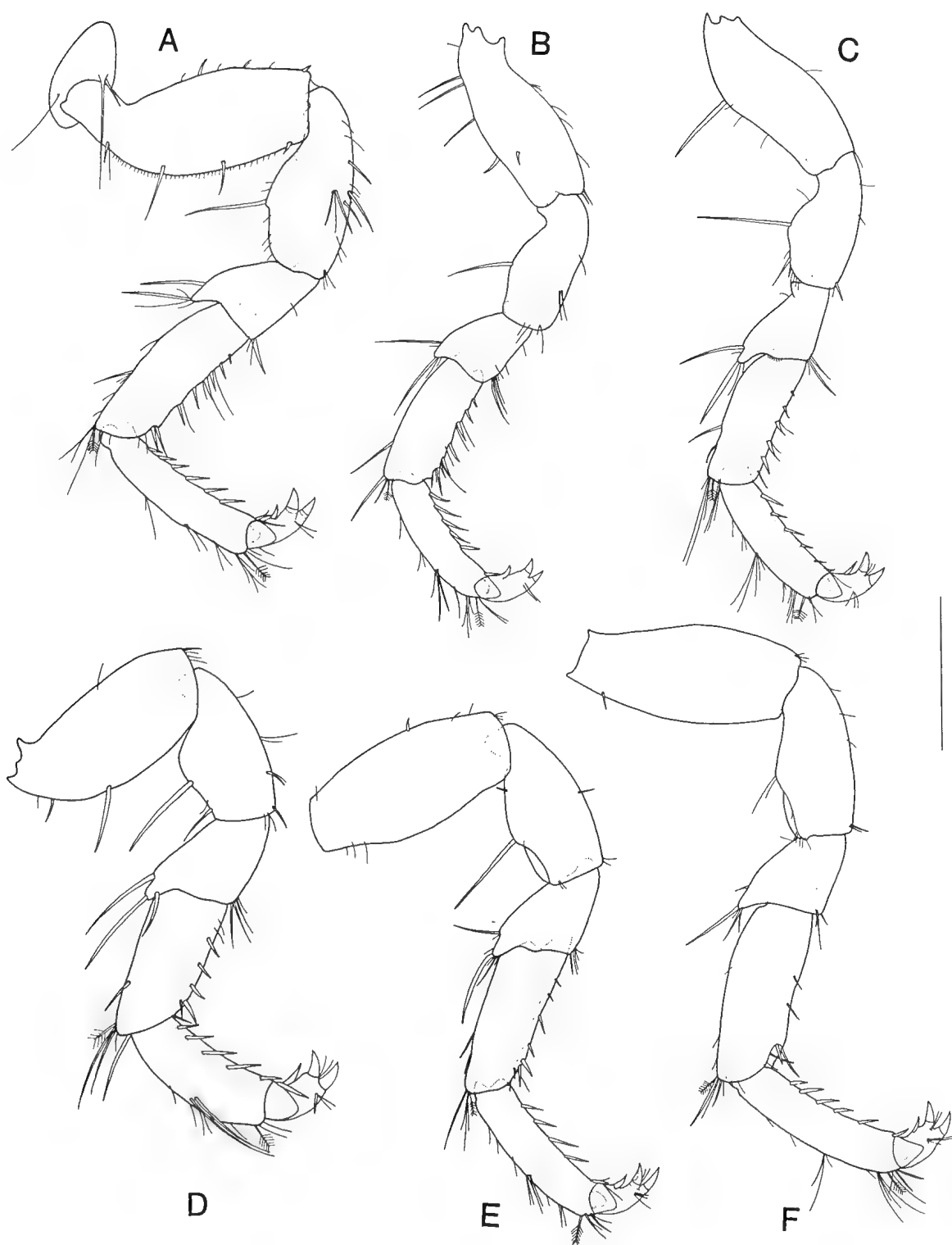


Fig. 22. *Stenetrium adrianae* n.sp. Paratype female (AM P.35651). A-F, pereopods II-VII. Scale bar = 0.5 mm.

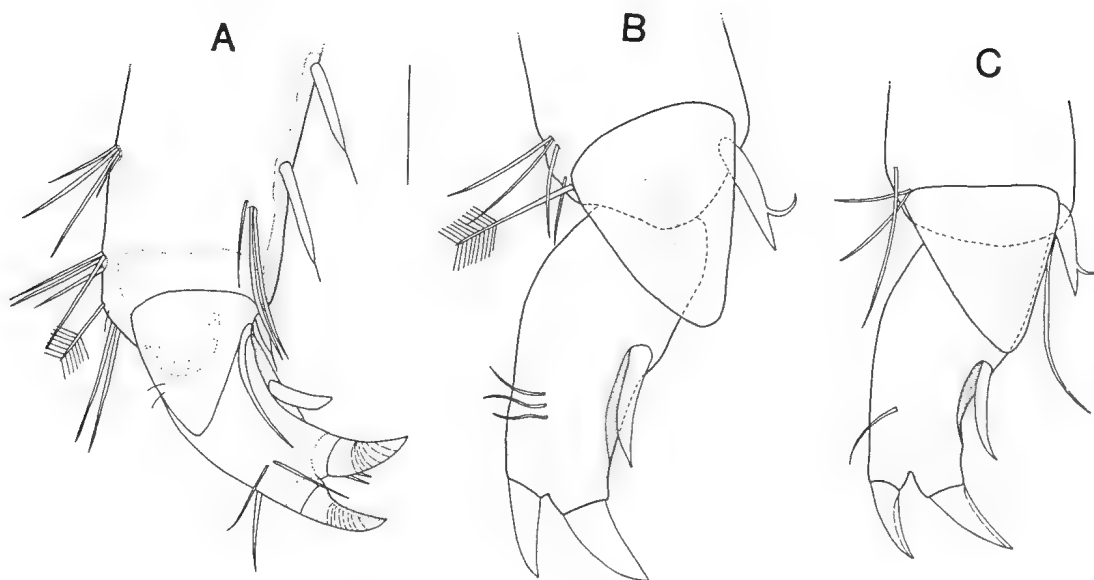


Fig. 23. *Stenetrium adrianae* n.sp. A,B, holotype male (AM P.42283). A, dactylus of pereopod II, male. B, dactylus of pereopod VII, paratype male (AM P.35651). C, paratype female (AM P.35651) dactylus of pereopod VII. Scale bar = 0.1 mm.

**Diagnosis.** Head frontal margin with weak lateral and antennal spines, antennal spines rounded and longer than blunt lateral spines. Eyes with circlet of few ocelli. Rostrum with broad base and narrow pointed tip. Antennular flagellum with 3 articles. Antennal article 1 without lateral spine. Maxilliped endopodite distal margin with 3 fan setae. Lateral margins of pereonites rounded; pereonites 1–4 subequal in length, longer than remaining pereonites; most pereonites with only 1 coxal lobe or spine visible in dorsal view. Male pereopod I with broad, robust propodus with denticulate setae and broad blunt teeth on propodal palm; dactylus equal in length to propodal palm; propodal palm terminal seta with small accessory seta and serrate ventral margin. Pleopod II protopod distal tip rounded without distal extension; exopod and endopod positioned subapically on medial margin. Appendix masculina elongate, tapering to needle-like stylet with long setae on lateral margin. Pleotelson elongate, with 3 free reduced pleonites; posterolateral spines reduced; postanal region roundly triangular, without posterolateral extensions.

**Remarks.** The species of this genus all possess heads with reduced lateral and antennal spines, eyes with few ocelli, narrow triangular rostrums, and appendices masculinae with long needle-like stylets. Although a stylet similar to *Stenetrium adrianae* occurs in this genus, the long setae on the stylet tip and the differences in the body shape, cephalon shape and the shape of the remaining pleopods clearly distinguish this genus as a separate unit.

### *Hansenium* n.gen.

Figs 1E,F, 3C

**Type species.** *Hansenium hanseni* (Nobili, 1906).

**Species included.** See Table 1.

**Etymology.** *Hansenium* is named in honor of H.J. Hansen, who provided the first definitive work on the Stenetriidae early in this century. The gender is neuter.

**Diagnosis.** Head with reduced lateral and antennal spines; antennal spines rounded to pointed, longer than pointed lateral spines. Rostrum short, broad and apically flattened, slightly longer than antennal spines. Antennular flagellum with 8–14 articles. Antennal article 1 lateral spine much reduced or absent. Maxilliped endopodite distal margin with 6 fan setae. Pereonites with angular margins on pereonites 1–4; pereonite 1 longer than remaining pereonites; single and double coxal spines on anterior pereonites. Pereon elongate, anterolateral corners of pereonites 1 and 2 in females with large unfused coxal extensions. Pereopod I with large, robust dactylus twice as long as propodal width; propodus reduced, palm serrate in both sexes, and with large terminal spine in males. Male pereopod I carpus lateral margin extended and serrate. Pleopod II appendix masculina elongate with blunt distal tip; tip with ring of cuticular hairs; exopod subapical with large protopodal apical extension. Pleotelson with 2 free pleonites. Pleotelson elongate with prominent posterolateral spines; postanal region smoothly rounded.

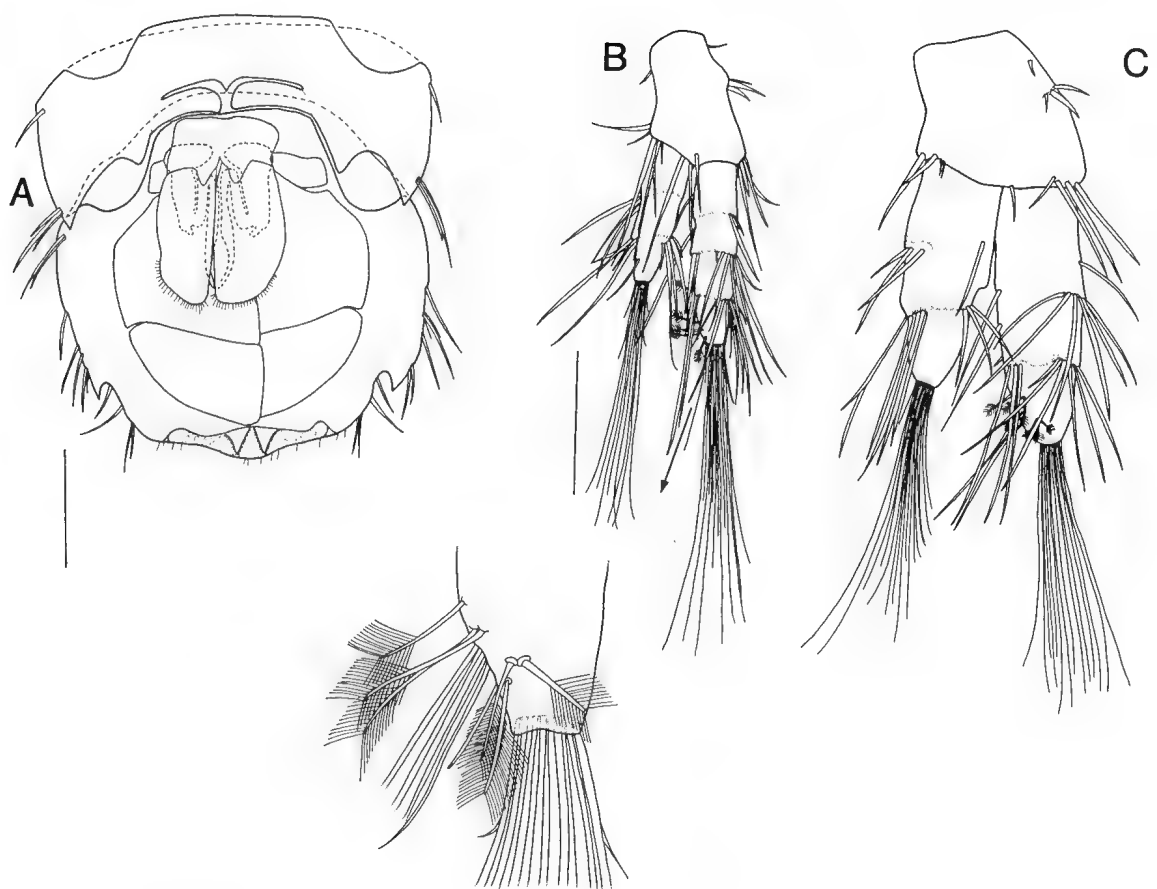


Fig. 24. *Stenetrium adrianae* n.sp. A,B, holotype male (AM P.42283). A, pleotelson, ventral view. B, male uropod with enlargement of endopod distal tip. C, paratype female (AM P.35651), female uropod. Scale bar = 0.5 mm.

**Remarks.** The genus *Hansenium* is most closely related to *Stenetrium* sensu stricto in overall morphology but can be distinguished most prominently by the large, pointed extended carpus that participates in grasping with an elongated dactylus. *Hansenium* also has large reniform eyes, reduced lateral spines and a broad short rostrum. A correction is made to the nomenclature of the species described as *S. caicosensis* Kensley & Heard, 1991 by changing it to *H. caicosense*, in order that the species name is consistent with the gender of the genus, i.e. neuter.

#### *Liocoryphe* n.gen.

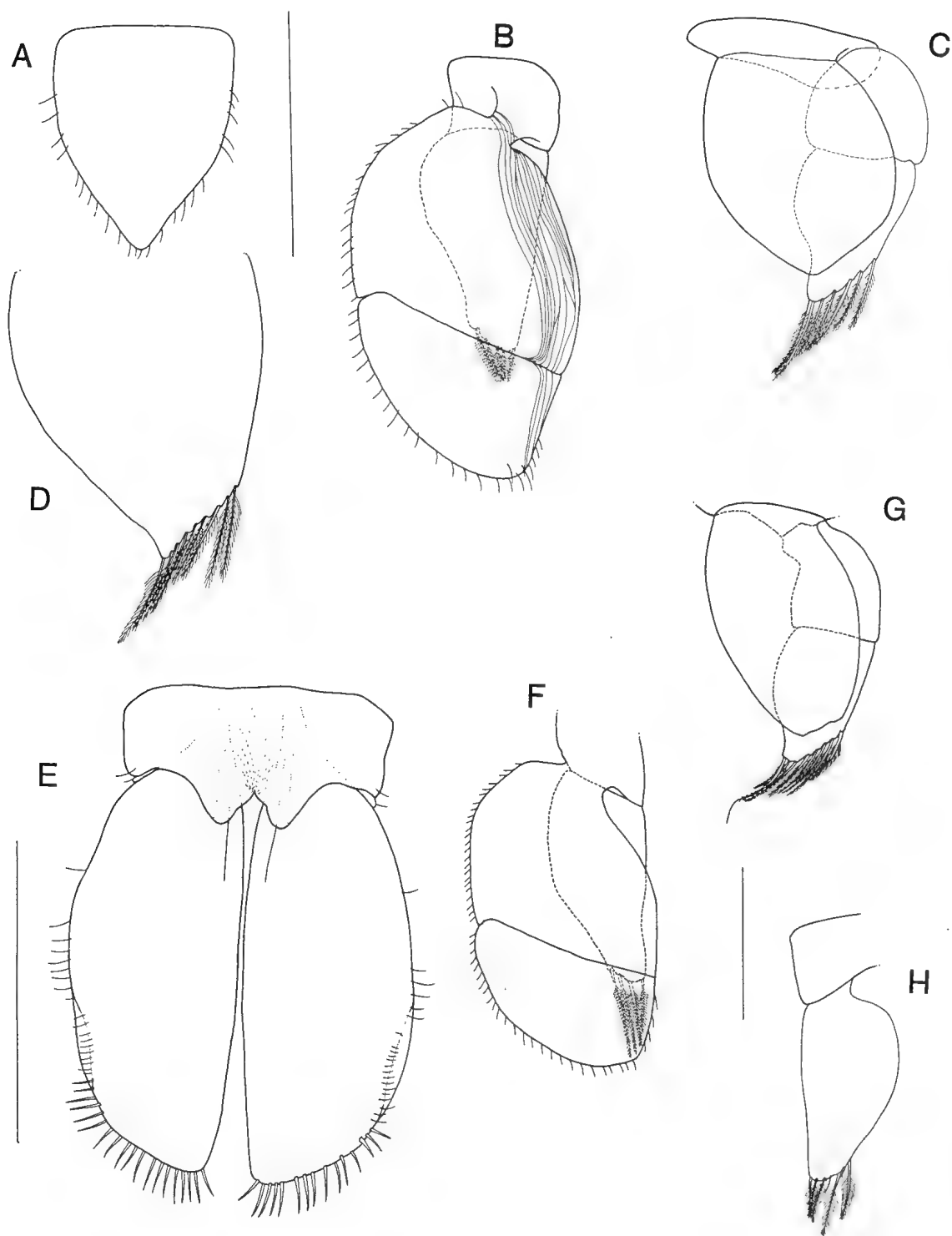
Figs 1G,H, 3D

**Type species.** *Liocoryphe minocula* (Menzies & Glynn, 1968).

**Species included.** See Table 1.

**Etymology.** *Liocoryphe* is derived from the Greek words "lios" meaning smooth, and "coryphe" meaning crown of the head. The name refers to the smooth head of this genus which lacks spines or lateral fields. The gender is feminine.

**Diagnosis.** Head dorsal surface smoothly rounded and frontal margin with no lateral spines, antennal spines rounded and much reduced, shorter than rostrum. Rostrum short, broad, rounded; eyes reduced to small rounded, anterolateral group of ocelli. Antennular flagellum with 4–6 articles. Antennal article 1 without lateral spines. Maxilliped endopodite distal margin with 4 fan setae. Pereonite lateral margins blunt to rounded; double coxal extensions visible on pereonites 2–4, single extensions on pereonites 5–6. Male pereopod I dactylus shorter than propodal palm; propodal palm serrate; carpus ventral margin with large, broad, blunt extension; male pereopod covered in long, dense setae from ischium to propodus. Male pleopod II protopod with small pointed apical extension; exopod subapical; appendix



**Fig. 25.** *Stenetrium adrianae* n.sp. **A–D**, paratype female (AM P.35651), pleopods II–V. **E–H**, holotype male (AM P.42283) pleopods I, III–V. Scale bar = 0.5 mm. Variation in plumose setae numbers between D and H due to damage during dissection.

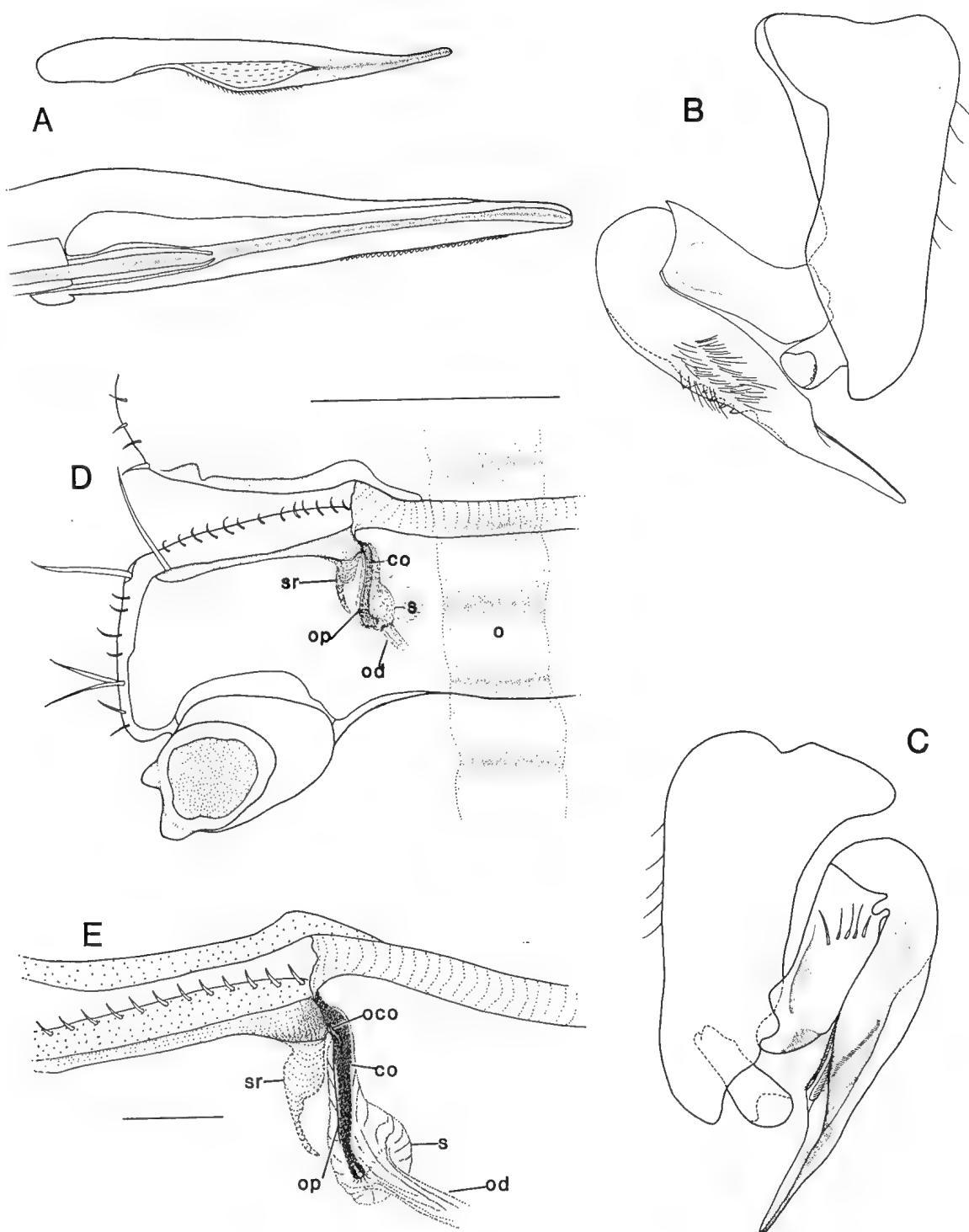


Fig. 26. *Stenetrium adrianae* n.sp. A–C, holotype male (AM P.42283). A, male pleopod II endopod, second segment medial view with enlargement of stylet tip. B, male pleopod II, dorsal view. C, male pleopod II, ventral view. D,E, preparatory female (AM P.35651), D, ventral view of pereonite 5, after clearing with KOH. E, enlargement of oopore region through ventral cuticle showing oopore (op) with stylet pocket (sp) and opening to cuticular organ (oco), cuticular organ (co) attached to the base of spermatheca (s) adjacent to oviduct (od). Scale bar = 0.5 mm.

masculina elongate with blunt distal tip and subapical row of short, proximally directed cuticular hairs, distal tip narrowed slightly. Pleotelson with 2 free pleonites. Pleotelson longer than wide, smoothly truncated to posterolateral spine then smoothly rounded with no telsonic projection between uropods.

**Remarks.** *Liocoryphe* is closely related to *Hanseni* and is distinguished by the males having an extended carpus. This genus gains separate generic status by lacking lateral spines on the head, having a small round group of ocelli, a short blunt rostrum, and a large blunt extension on the carpus that does not participate in grasping with the dactylus.

### *Mizothernar* n.gen.

Figs 2A,B, 3E

**Type species.** *Mizothernar patulipalma* (Kensley, 1984a).

**Species included.** See Table 1.

**Etymology.** *Mizothernar* is derived from the Greek words "mizon" meaning larger, and "thenar" meaning flat of the hand or palm. The name refers to the propodal palm of first pereopod, which is larger than in most stenetriids. The gender is neuter.

**Diagnosis.** Small bodied (2–3 mm), elongate stenetriid. Head frontal margin with no lateral spines, antennal spines weak but longer than rostrum; rostrum much reduced and bilobed; eyes small, round, anterolateral groups of up to 10 ocelli set close to lateral margin. Antennular flagellum with 4 articles, second article longer than remaining articles. Antennal article 1 without lateral spine. Maxilliped endopodite distal margin with 3 fan setae. Pereonite lateral margins rounded; pereonite lengths subequal. Pereopod I not sexually dimorphic but extremely broad and rounded, larger than cephalon; as long as broad; dactylus as long as propodal palm. Female pleopod II shield shaped with deep, narrow apical notch. Male pleopod II appendix masculina elongate with blunt distal tip and subapical row of short, proximally directed cuticular hairs. Pleopod IV endopod styliform. Pleotelson strawberry shaped with weak posterolateral spines, with 3 reduced free pleonites.

**Remarks.** The two closely related species of *Mizothernar* are distinguished from the other genera by possessing a largely gnathostenetroidid habitus that includes the absence of lateral spines, reduced antennal spines, and bilobed, reduced rostrum on the cephalon; short appendix masculina, styliform exopod of pleopod 4; and small body size. The other pleopods, pereopod I and the presence of sternal keels along the ventral midline are, however, distinctly stenetrioid in form. A closer examination of these species may throw more light on the

relationships between the two superfamilies, Stenetrioidea and Gnathostenetrioidea.

### *Protallocoxa* Schultz, 1978

Figs 2C,D, 3F

*Protallocoxa* Schultz, 1978: 246–250, figs 1A–K, 2A–J.

*Protallocoxa*.—Schultz, 1979b: 78–79, figs 3–4. *Stenetrium*.—Wilson, 1980: 219–221.

**Type species.** *Protallocoxa weddellensis* Schultz, 1978.

**Species included.** See Table 1.

**Diagnosis.** Head wider than long with broad lateral spines and antennal spines almost absent. Rostrum robust, elongate, roundly pointed, as long as cephalon with smooth lateral margins. Eyes small, anterolateral reniform. Maxilliped endopodite distal margin with 7–8 fan setae; epipod with rounded distal tip. Antennal article 1 without lateral spines. Antennular flagellum with 10–20 articles. Pereon robust with smoothly rounded lateral margins; coxae not visible in dorsal view. Male pereopod I propodus as long as wide, with setose propodal palm lacking teeth; dactylus equal to length of propodal palm. Male pleopod II protopod with small distal extension; exopod and endopod subdistal on medial margin; appendix masculina elongate with blunt distal tip and small subapical row of short, proximally directed cuticular hairs. Female pleopod II apex acutely pointed. Pleotelson lateral margins smooth and posteriorly truncated, with weak posterolateral spines, telsonic region between uropods sharply truncated. Uropods short, barely emerging from pleotelson margin in dorsal view.

**Remarks.** The use of plesiomorphic and/or variable characters while ignoring other diagnostic features has clouded the definition of this genus. *Protallocoxa* Schultz, 1978 originally was based on a freely-articulating, protruding coxa of the first pereopod. Schultz (1978) considered this character to be a primitive asellote feature and used it as a justification for a new superfamily, the Protallocoxoidea. Wilson (1980) later showed that this feature was a plesiomorphic condition in brooding females of many asellote species, including *Stenetrium*, and synonymised Schultz's taxon back into the Stenetriidae as *S. weddellense*. In our proposed classification, *Protallocoxa* regains its generic status within the family because the member species, *P. weddellense* and *P. abyssale* have several unique features among the Stenetriidae, particularly a lack of coxal projections visible in dorsal view and reduced marginal spines on the body.

*Stenobermuda* Schultz, 1979a.

Figs 2E,F, 3G

*Stenobermuda* Schultz, 1979a: 905–907, figs 1–11.*Stenobermuda*.—Kensley & Schotte, 1989: 106, fig. 48.*Stenetrigus*.—Schultz, 1982: 58–59, figs 32, 33.**Type species.** *Stenobermuda acutirostrata* Schultz, 1979a.**Species included.** See Table 1.

**Diagnosis.** Head frontal margin with robust sharply triangular lateral spines, antennal spines reduced. Rostrum robust and long with narrowly tapered point; rostrum longer than lateral spines. Eyes consist of small circlet of 4–5 ocelli. Antennal article 1 without lateral spine. Antennular flagellum with 3–4 articles. Maxilliped endopodite distal margin with 3 fan setae. Pereonites subequal in length with angular lateral margins. Male pereopod I dactylus equal to width of propodal palm; pereopod I elongate with narrow propodus. Male pleopod II exopod situated apically; appendix masculina elongate, narrowing distally with terminal cuticular fan, setae-like cuticular hairs and laterally directed stylet. Female pleopod II basally narrow, broadening to a round opercular shield, lacking apical notch. Pleotelson with 3 free pleonites. Pleotelson as long as wide, smooth lateral margins, gently truncated to reduced posterolateral spines then roundly triangular with no posterolateral projections between uropods.

**Remarks.** Schultz (1979a) created a third genus, *Stenobermuda*, using features common to many, if not all Stenetriidae. The only apomorphic feature mentioned (only in the species description) was a unique and complex distal segment of male pleopod II of *Stenobermuda acutirostrata* (Richardson, 1902). Important characters (not included in the original generic concept) include the female pleopod II shape, the shape and dimensions of pleopods III–IV, and the narrow pereopod I.

*Stenetrigus* was created by Schultz (1982) for *Stenetrium syzygus* Barnard, 1940 using the following features: eyes of few ocelli; male pleopod II without fused sympod; possible hermaphroditism; no posterolateral notch on the pleotelson; long anterolateral and “antennal spines” and a long, acutely pointed rostrum; manus simple, toothed with plumose setae on ventral margin of propodus. This combination of features, although rare, is not unique among the stenetriids. *Stenobermuda acutirostrata* (Richardson, 1902) is similar to *S. syzygus* in many respects, particularly the ones used here to define *Stenobermuda*. The absence of the posterolateral notches on the pleotelson is the only difference between the two species, which is not a genus-level feature. As with the description of *Stenobermuda*, the structure of pleopods III–V and the male pleopod II of *S. syzygus*, which closely resembles that of *Stenobermuda*, were not mentioned in the original description of Schultz, 1982.

Owing to the similarities of the two species mentioned above, both genera are synonymised, with the name *Stenobermuda* having priority. The possible hermaphroditism or similarity of the pleopods between the male and female alluded to by Schultz (1982: 58–59) cannot be evaluated further because Barnard’s (1940) “female” specimen was not available to Schultz for inspection.

*Tenupedunculus* Schultz, 1982

Figs 2G,H, 3H

*Tenupedunculus* Schultz, 1982: 54–58, figs 30–31.**Type species.** *Tenupedunculus elongatus* Schultz, 1982**Species included.** See Table 1.

**Diagnosis.** Head angular, broader than long with elongate, acutely pointed lateral spines extending past rostrum. Rostrum small rounded, extending slightly past antennal spine. Eyes reniform of about 20 ocelli. Antennal article 1 without lateral spine. Antennular flagellum with 12–24 articles. Pereonites 1–4 with sharply produced anterolateral corners, double coxal lobes visible in dorsal view. Male pleopod II protopod with small, pointed apical extension; appendix masculina elongate, narrow, distal tip rounded laterally but weakly pointed on medial margin with subdistal lateral setal ridge; exopod and endopod subapical on medial margin. Female pleopod II with distal half narrowing sharply to rounded point. Pleotelson with 2 free pleonites. Pleotelson with weak posterolateral spines, prominent posterolateral and medial cuticular extensions. Uropods large.

**Remarks.** The unifying features of *Tenupedunculus* include the shape of the male pleopod I, the appendix masculina of pleopod II, the number of dorsally visible coxal lobes, and a head with large, robust lateral spines and reduced antennal spines. The degree of enlargement of the lateral spine and reduction of the antennal spine varies throughout the genus from the extreme cases as seen in *Stenetrium acutum* and *Stenetrium inflectifrons* to the more subdued forms of *Stenetrium pulchrum* and *Stenetrium drakensis* (nec *Protallocoxa*). *S. drakensis* was placed in this genus, even though no males were collected, because of its close resemblance with *Stenetrium beddardi* in the cephalon armature, the pleotelson shape and the presence of 2 coxal lobes on pereonite I. Schultz (1982) also noted a close resemblance between these two species.

The concept of *Tenupedunculus* Schultz, 1982 was based on lack of eyes in *T. elongatus*, a dubious diagnostic feature (cf. Wolff, 1962; Hessler & Wilson, 1983). All other features used in Schultz’s (1982) description do not unequivocally define the new genus among all stenetriids. Schultz (1982) even states that the “male pleopod 2 and others [are] *Stenetrium* like”.



The similarities to *Stenetrium pulchrum* and *Stenetrium haswelli* in the male pleopods, the pleotelson and the dorsally visible coxal lobes of *T. elongatus*, however, place this species within this genus. Although *T. elongatus* does not represent the typical form of this genus as seen in *S. acutum* and *S. inflectifrons*, the genus name is valid and has priority. Therefore *Tenupedunculus* is used as the name for this genus. *Tenupedunculus* may be further separated into two groups after closer examination of the types.

### Biogeographical Distributions

The proposed generic groupings have resulted in three distinct geographical regions for the distribution of the Stenetriidae. *Stenetrium* sensu stricto is a shallow water group distributed from a region including New Zealand to the western side of South Africa, taking in all of southern Australia. The deep ocean component of this region contains members of *Protallocoxa*. *Tenupedunculus* is a deep ocean assemblage encompassing the second region, around the southern tip of South America to Antarctica.

The remaining five genera are circumtropical with considerable overlap between the genera. They inhabit the littoral and sublittoral zones, principally in coral reef biomes. In all stenetriid genera, body spinosity increases with increasing latitude in the southern hemisphere, although the reasons for this geographic pattern are not apparent.

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Table 1. Genera and species of the Stenetriidae Hansen, 1905. Original generic designations and species spelling retained.

Species	Locality	Depth
<b>Superfamily Stenetriioidea</b> Hansen, 1905		
<b>Family Stenetriidae</b> Hansen, 1905		
<i>Stenetrium</i> Haswell, 1881 sensu stricto		
<i>Stenetrium adrianae</i> n.sp.	Eden, Australia	littoral
<i>Stenetrium armatum</i> Haswell, 1881	Sydney, Australia	littoral
<i>Stenetrium bartholomei</i> Barnard, 1940	Still Bay, South Africa	littoral
<i>Stenetrium crassimanus</i> Barnard, 1914	False Bay, South Africa	littoral
<i>Stenetrium dagama</i> Barnard, 1920	Cape Point, South Africa	420 m
<i>Stenetrium dalmeida</i> Barnard, 1920	Cape Point, South Africa	270–460 m
<i>Stenetrium diazi</i> Barnard, 1920	Buffels Bay, South Africa	littoral
<i>Stenetrium esquartum</i> Schultz, 1982	False Bay, South Africa	littoral
<i>Stenetrium glauerti</i> Nicholls, 1929	Rottneest Island, Western Australia	littoral
<i>Stenetrium macrochirum</i> Nicholls, 1929	Rottneest Island, Western Australia	littoral
<i>Stenetrium magnimanum</i> Schultz, 1982	False Bay, South Africa	littoral
<i>Stenetrium mediterraneum</i> Hansen, 1905	Siracusa, Sicily	littoral
<i>Stenetrium perestrelloi</i> Kensley, 1984b	East London, South Africa	90 m
<i>Stenetrium saldanha</i> Barnard, 1920	Saint Blaize, South Africa	0–246 m
<i>Stenetrium serratum</i> Hansen, 1905	Virgin Islands	littoral
<i>Stenetrium spinorostrum</i> Nicholls, 1929	Rottneest Island, Western Australia	littoral
<i>Stenetrium truncatum</i> Nicholls, 1929	Rottneest Island, Western Australia	littoral
<i>Stenetrium vemae</i> Kensley, 1980	Vema Seamount, South Africa	40 m
<b>Tristenium</b> n.gen.		
<i>Stenetrium acutirostrum</i> Müller, 1991a	Straits of Bab el Mandeb	235 m
<i>Stenetrium bourboni</i> Müller, 1991c	Reunion Island	littoral
<i>Stenetrium temae</i> Müller, 1991b	Moorea	littoral
<b>Hansenium</b> n.gen.		
<i>Stenetrium antillense</i> Hansen, 1905	West Indies	littoral
<i>Stenetrium bowmani</i> Kensley, 1984a	Belize	littoral
<i>Stenetrium caicosense</i> Kensley & Heard, 1991	Belize	littoral
<i>Stenetrium chiltoni</i> Stebbing, 1905	Gulf of Manaar, Ceylon	littoral
<i>Stenetrium dodo</i> Müller, 1991c	Reunion Island	littoral
<i>Stenetrium entale</i> Nordenstam, 1946	Gilbert Island	littoral
<i>Stenetrium gilbertense</i> Nordenstam, 1946	Gilbert Island	littoral
<i>Stenetrium hansenii</i> Nobili, 1906	Tuamotu Island	littoral
<i>Stenetrium medipacificum</i> Miller, 1941	Hawaii	littoral
<i>Stenetrium occidentale</i> Hansen, 1905	Saint Thomas Island, West Indies	littoral
<i>Stenetrium spathulicarpus</i> Kensley, 1984a	Belize	littoral
<i>Stenetrium stebbingi</i> Richardson, 1902	Bailey Bay, Bermuda	littoral
<i>Stenetrium wilsoni</i> Müller, 1991b	Moorea	littoral
<b>Liocoryphe</b> n.gen.		
<i>Stenetrium algretti</i> Müller, 1991b	Bora Bora	littoral
<i>Stenetrium gertrudae</i> Müller, 1991c	Reunion Island	littoral
<i>Stenetrium minocule</i> Menzies & Glynn, 1968	Puerto Rico	littoral
<i>Stenetrium siamense</i> Hansen, 1905	Gulf of Thailand	littoral
<i>Stenetrium</i> sp. Carpenter & Magniez, 1982	Curaçao	marine cave

Table 1. Continued.

Species	Locality	Depth
<b><i>Mizothenar</i> n.gen.</b>		
<i>Stenetrium maharepa</i> Müller, 1991b	Moorea	littoral
<i>Stenetrium patulipalma</i> Kensley, 1984a	Belize	littoral
<b><i>Protallocoxa</i> Schultz, 1978</b>		
<i>Protallocoxa weddellensis</i> Schultz, 1978	Weddell Sea, Antarctica	2818 m
<i>Stenetrium abyssale</i> Wolff, 1962	Kermadec Trench, New Zealand	4540 m
<b><i>Stenobermuda</i> Schultz, 1979a</b>		
<i>Stenetrium acutirostrata</i> Richardson, 1902	Bermuda	5 m
<i>Stenetrium syzygus</i> Barnard, 1940	Still Bay, South Africa	littoral
<i>Stenobermuda iliffei</i> Kensley, 1994	Bermuda	cave
<b><i>Tenupedunculus</i> Schultz, 1982</b>		
<i>Stenetrium acutum</i> Vanhöffen, 1914	Gauss Station, Davis Sea	3397 m
<i>Stenetrium beddardi</i> Kussakin, 1967	Southern Argentina	680 m
<i>Stenetrium dentimanum</i> Kussakin, 1967	Southern Argentina	680 m
<i>Stenetrium haswelli</i> Beddard, 1886	Rio del la Plata	1097 m
<i>Stenetrium inflectofrons</i> Schultz, 1982	Scotia Sea, Antarctica	588 m
<i>Stenetrium pulchrum</i> Schultz, 1982	Southern Argentina	1911 m
<i>Stenetrium serraticaudum</i> Kussakin & Vasina, 1984	South Atlantic	500 m
<i>Stenetrium smirnovi</i> Vasina, 1982	Patagonian Shelf	500 m
<i>Stenetrium virginale</i> Schultz, 1982	Scotia Sea, Antarctica	567 m
<i>Tenupedunculus drakensis</i> Schultz, 1982	Terra Del Fuego, Argentina	548 m
<i>Tenupedunculus elongatus</i> Schultz, 1982	Vema, SE Argentine Basin	4696 m
<b><i>Incertae sedis</i> (insufficient data)</b>		
<i>Jaera filicornis</i> Grube, 1886	Adriatic Sea	littoral
(suggested to be synonymous with <i>J. longicornis</i> by Richardson, 1910)		
<i>Jaera longicornis</i> Lucas, 1849	Algeria	littoral
(type species of <i>Jamna</i> Bovallius, 1886)		
<i>Stenetrium euchirum</i> Nobili, 1906	Tuamotu Island	littoral
<i>Stenetrium fractum</i> Chilton, 1884	Lyttelton Harbour, New Zealand	littoral
<i>Stenetrium monodi</i> Nordenstam, 1946	Gulf of Suez	littoral
<i>Stenetrium proximum</i> Nobili, 1907	Tuamotu Island	littoral
<i>Stenetrium rotundatum</i> Vanhöffen, 1914	Gauss Station	385 m

## A Taxonomic Revision of the *Cyclodomorphus casuarinae* Complex (Squamata: Scincidae)

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**ABSTRACT.** Univariate and multivariate analyses of geographic variation in morphological characters indicate that *Cyclodomorphus casuarinae* consists of three geographically distinct taxa, which are recognised as species: one in Tasmania (*C. casuarinae*), a new species in the Australian Alps, and the third at lower altitudes in mainland Australia (*C. michaeli*). These three species are described, and data on habitat and reproduction provided for each.

SHEA, G.M., 1995. A taxonomic revision of the *Cyclodomorphus casuarinae* complex (Squamata: Scincidae). Records of the Australian Museum 47(1): 83–115.

The she-oak skink, *Cyclodomorphus casuarinae*, is a poorly known, secretive and uncommonly collected species from south-eastern Australia and Tasmania. Although this large and spectacular species occurs in close proximity to two state capital cities (Sydney and Hobart), and has been known to science for over a century and a half, it has received almost no attention, either taxonomically or ecologically (Shea, 1988; Shine & Hutchinson, 1991). The species is considered to be rare and under threat in at least the Victorian part of its range (Ahern *et al.*, 1985; Cherry *et al.*, 1987; MacFarlane *et al.*, 1987).

With two exceptions (Peters, 1875; Wells & Wellington, 1984), no author has suggested that the taxon consists of other than a single monotypic species. However, until now, no author has examined representative series of specimens from throughout the range of the taxon. Indeed, there are only three redescrptions based on more than a single specimen: by Gray (1845)

based on five unlocalised Tasmanian specimens, by Boulenger (1887) based on 16 unlocalised Tasmanian specimens and a single Sydney specimen, and by Mitchell (1950) based on six unlocalised Tasmanian specimens. None of these accounts were able to consider geographic variation.

Although it has broad altitudinal limits, from sea level up to the Australian Alps (Loveridge, 1934), and has been reported from a number of different habitats, including dry sclerophyll forest, woodlands, heathlands, swamplands, tussock grasslands, coastal plains and grazing lands, sand dunes, river flats, valleys and ranges (Cogger, 1986; Wilson & Knowles, 1988; Ehmann, 1992), *C. casuarinae* has a fragmented distribution, with several geographic isolates (Rawlinson, 1974; Wells & Wellington, 1984, 1989; MacFarlane *et al.*, 1987; Mansergh & Bennett, 1989; Swan, 1990; Richards *et al.*, 1990; Bennett *et al.*, 1991; Ehmann, 1992). This distribution is unlike that of any other species of

Australian reptile. In this paper, I explore geographic variation in the external morphology of these populations, and recognise and define three species each currently referred to by the name *Cyclodomorphus casuarinae*.

### Materials and Methods

All specimens in most Australian museum collections were examined, together with type material held in European museums. Collection acronyms are: AM – Australian Museum, Sydney; ANWC – Australian National Wildlife Collection, Canberra; MNHP – Muséum Nationale d'Histoire Naturelle, Paris; MV – Museum of Victoria, Melbourne; NTM – Northern Territory Museum, Darwin; QM – Queensland Museum, Brisbane; QVM – Queen Victoria Museum, Launceston; SAM – South Australian Museum, Adelaide; TM – Tasmanian Museum, Hobart; ZMB – Zoologisches Museum, Berlin.

**Character definitions.** Head shield nomenclature follows Taylor (1935: 71) and Shea (1992). In the case of presubocular scales, three scales were usually present in this region. However, there was much variation in the size of the second scale, from a large element completely separating the first and third scales and reaching the supralabial series, to a small element lying dorsal to the third scale, or even absent. In order to standardise the counts for this character, I counted as presubocular scales only those scales contacting the supralabial series, thus excluding this second scale in many cases. The nomenclature for temporal scale configurations follows Shea & Miller (in press). Head shields were counted on both sides where possible, with the exception of palpebrals, counted only on the left side, and are numbered from rostral to caudal. Where two counts are given for an individual, the first count is for the left side.

Midbody scales were counted around the body at the mid-point of the axilla-groin interval. Paravertebral scales were counted, generally on the left side, from the first scale caudal to the parietals, to the last scale cranial to the level of the cranial margin of the hindlimbs. Subcaudal scales were counted, on original tails only, from the cranialmost scale approximately equal in size to adjacent lateral caudal scales, caudal to and including the terminal caudal scale. Subdigital lamellae were counted bilaterally on the fourth toe from the first scale just beyond the edge of the sole, to and including the scale bordering the claw.

Non-cephalic measurements follow Greer (1982) and Cogger (1986). Head length is from the rostral margin of the ear to the tip of the snout; head width is across the widest point of the head, rostral to the ear, and head depth is vertically from the highest point of the parietal table. Head measurements were made with dial calipers to the nearest 0.1 mm. All other measurements were made to the nearest 0.5 mm with a steel rule. The following measurement acro-

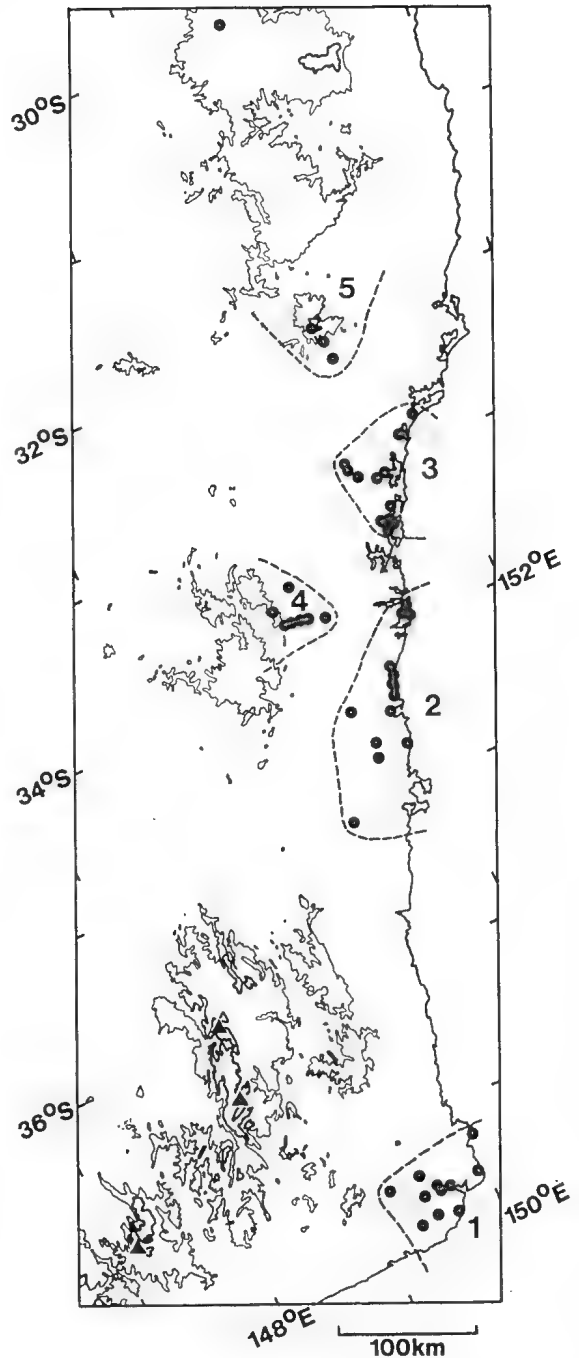


Fig. 1. Distribution of members of the *C. casuarinae* complex on mainland Australia. Dots are *C. michaeli*, triangles are *C. praealtus*. Dashed lines and numbers indicate populations of *C. michaeli* used for analysing geographic variation, as follows: 1, Eden; 2, Illawarra; 3, Central Coast; 4, Blue Mountains; 5, Barrington Tops. Thin solid lines represent 1000 m contour; thicker solid lines represent 1500 m contour.

nyms are used throughout the text: SVL – snout-vent length; AGL – axilla-groin length; TL – tail length; FLL – forelimb length; HLL – hindlimb length; HL – head length; HW – head width; HD – head depth. Because of significant allometry in all measurements, data are presented in two forms: the more traditional range of ratios, allowing comparison with previous



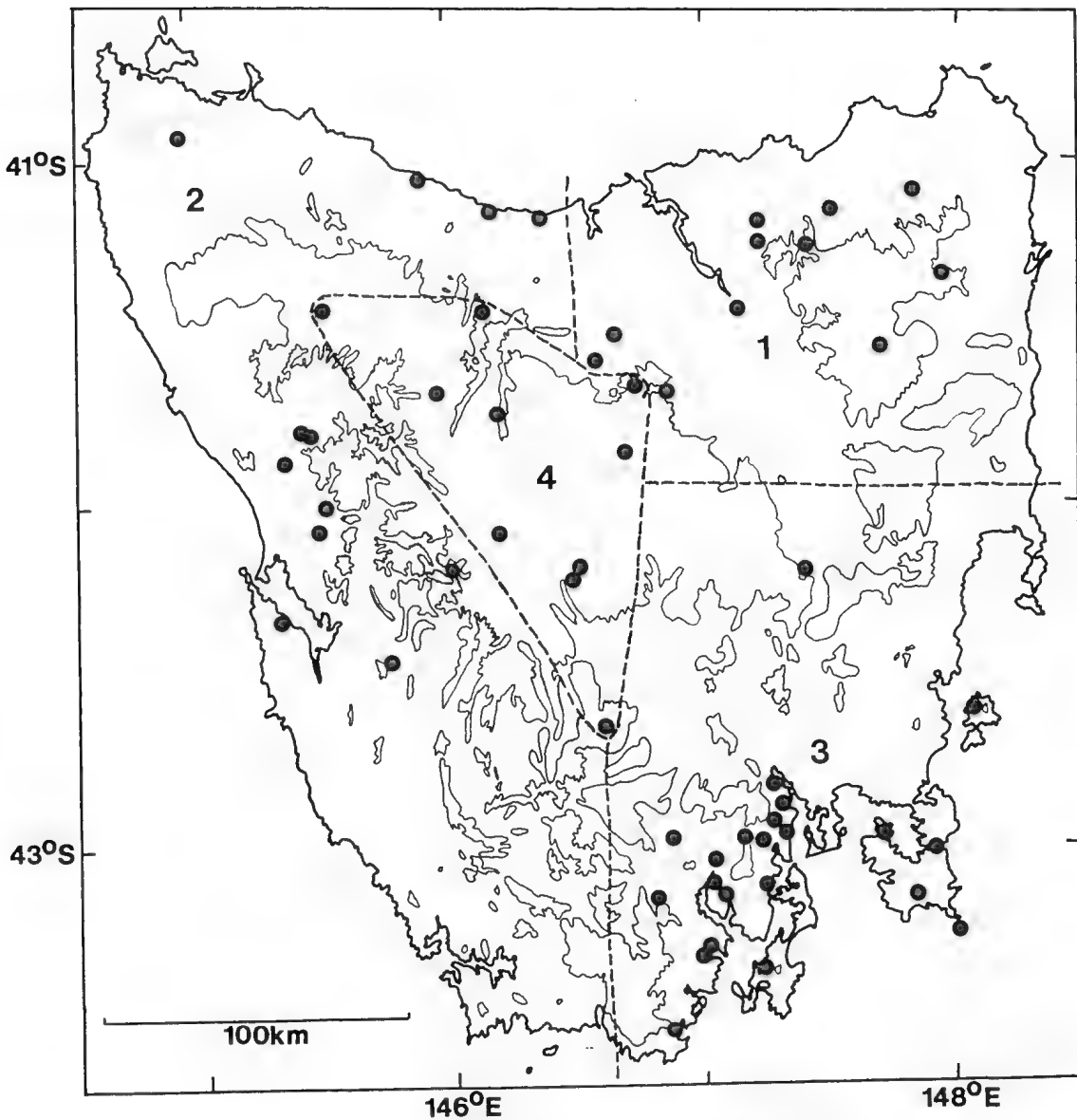


Fig. 2. Distribution of *C. casuarinae* in Tasmania. Dashed lines and numbers indicate populations used for analysing geographic variation, as follows: 1, north-east; 2, north-west; 3, south-east; 4, central. Solid lines represent 500 m contour.

studies, and allometric correlations, expressing the degree of allometry and allowing more detailed comparisons between sexes and taxa.

**Geographic variation.** For analysis of geographic variation, specimens were grouped into geographic subunits (populations) in two ways. On the mainland, specimens were grouped on the basis of geographic proximity and the existence of collecting gaps. From the large number of specimens of other reptiles from these intervening regions available in museum collections, I consider these gaps to represent real regions of absence rather than a lack of collecting effort. Six

mainland populations were recognised: an alpine population (Australian Alps), three largely coastal populations (from south to north: Eden, Illawarra and Central Coast), a Blue Mountains population, and a Barrington Tops population (Fig. 1). The latter population includes a single specimen from much further north, near Ben Lomond on the New England tableland. In Tasmania, no distributional discontinuities were apparent, and four populations were eventually arbitrarily differentiated by altitude, latitude and longitude to give three almost exclusively lowland populations (below 500 m a.s.l.) in the north-east, north-west and south-east and a central highland population above 500 m a.s.l. (Fig. 2).

Quantitative scalational characters were tested for geographic variation by one-way analysis of variation (ANOVA). Where significant variation was present, multiple pairwise comparisons of all pairs of populations were made by Gabriel's approximation to the GT2 method (Sokal & Rohlf, 1981) at a 5% level of significance.

Two qualitatively-scored scalational characters (degree of separation/contact of nasal and prefrontal shields) were re-scored as follows: separated – 1; point to narrow contact – 2; moderate to broad contact – 3. Analysis of variance and multiple pairwise comparisons were then carried out on these scores.

Minimum SVL at maturity was determined for three population groups (Tasmania, Australian Alps and other mainland groups) by the presence of enlarged, turgid testes 6 mm or more in length in males and oviducal embryos or enlarged yolking oviducal follicles 5.5 mm or more in diameter in females. All animals greater than the minimum mature size were considered mature. Differences in adult size were assessed by Mann-Whitney U tests, treating sexes separately.

Other morphometric characters showed allometric growth compared to SVL. The effects of allometric growth were removed by the following steps. All metric characters were converted to natural logs. Characters were regressed against SVL using the allometric growth formula  $\ln(y) = a \ln(x) + b$ , where  $y$  is the allometric variable and  $x$  is SVL (Thorpe, 1975), for each of the following three groups: Tasmanian populations, Australian Alps and other mainland populations. Allometric character states were then adjusted to the values they would assume if the specimen were of uniform body size by fitting the mean value of  $a$  for the three groups and the overall mean SVL (100 mm) to the equation (Thorpe, 1975)

$$y = e^{\ln(yi) - a(\ln(xi) - \ln(x))}$$

where  $y$  is the adjusted dependent variable,  $yi$  is the unadjusted dependent variable,  $xi$  is the SVL for that individual, and  $x$  is the mean SVL (100 mm) (see also Sokal & Rohlf, 1969: 442–445). Analysis of variance and multiple pairwise comparisons were then carried out on the adjusted values.

Initial univariate analyses indicated that tail characters (number of subcaudal scales and tail length) gave complete or nearly complete separation of three groups of populations (see below). However, as these characters were only scorable on some animals, a canonical variates analysis was performed, using specimens as units, scores for all other characters showing geographic variation (except palpebrals, which were not scored on many animals), and the ten populations as *a priori* groups.

Sexual dimorphism in all scalational characters showing geographic variation was tested by t-tests within species. Sexual dimorphism in metric characters was tested by analysis of covariance.

Analysis of variance was carried out by the statistical package MICROSTAT Ver. 4.1 (Ecosoft, 1984), while

analysis of covariance and canonical variates analysis were carried out by SYSTAT Ver. 4.0 (Wilkinson, 1987).

In presenting the results of statistical tests, subscripted values indicate degrees of freedom, while the superscripts \*, \*\*, \*\*\* indicate significance at 5%, 1% and 0.1% levels respectively. All t-tests and Mann-Whitney U tests are two-tailed.

## Geographic variation

Significant geographic variation was not detected in head depth. All other characters tested for geographic variation had significant variation.

Nasals: ANOVA:  $F_{9,221} = 5.495^{***}$ . Means for quantitatively-scored degree of separation/contact ranged from 1.2 (north-east Tasmania) to 2.4 (north-west Tasmania). Significant differences were detected only between the four highest means and four lowest means, and then only between some pairs: north-west Tasmania vs north-east Tasmania, Eden (1.3), south-east Tasmania and Blue Mountains (1.6); Alps (2.3) vs south-east and north-west Tasmania and Eden; Central Coast (1.9) and Illawarra (1.8) vs north-west Tasmania).

Prefrontals: ANOVA:  $F_{9,221} = 5.714^{***}$ . Means for quantitatively-scored degree of separation/contact were mostly between 2.7 (Alps, central Tasmania) and 3.0 (Barrington, Central Coast), with only the three lowland Tasmanian populations lower (north-west Tasmania, 2.2; north-east and south-east Tasmania, 2.4). The only significant differences detected were between the latter three populations vs Central Coast, Illawarra (2.9) and Blue Mountains (2.8), and between south-east Tasmania and Eden (2.9). Thus, there was a trend towards more narrowly contacting prefrontals in Tasmania.

Nuchals: ANOVA:  $F_{9,444} = 9.214^{***}$ . Two groups of means were apparent. North-east, central and south-east Tasmania had low means (2.1–2.3) while mainland populations, together with north-west Tasmania, had high means (2.6 [Barrington] – 3.2 [Central Coast]). Significant differences were found between the three low Tasmanian means and Central Coast, Blue Mountains, north-west Tasmania and Eden, and in the case of north-east and central Tasmania, also with Australian Alps and Illawarra.

Presuboculars: ANOVA:  $F_{9,450} = 5.222^{***}$ . Means ranged from 2.0 (Barrington, Central Coast, Eden) to 2.4 (Illawarra), with the only significant differences between Illawarra vs Central Coast and Eden vs south-east Tasmania (2.1).

Postsuboculars: ANOVA:  $F_{9,448} = 4.386^{***}$ . Means ranged from 3.2 (Eden, Alps) to 3.7 (north-west Tasmania). The alpine population differed significantly from Illawarra (3.6), north-west Tasmania and south-east Tasmania (3.6). The Eden population also differed significantly from Illawarra and north-west Tasmania, while the Central Coast (3.3) differed significantly from Illawarra.

Supraciliaries: ANOVA:  $F_{9,449} = 9.703^{***}$ . Means for all but one population were in the range 5.7 (Illawarra) to 6.0 (Barrington, all four Tasmanian populations) with mode six. The alpine population had mode five and mean 5.3, significantly different to all other populations. The only other significant differences were between Illawarra and north-west/south-east Tasmania.

Infralabials: ANOVA:  $F_{9,445} = 4.826^{***}$ . Means for all but two populations were in the range 7.1 (Central Coast) to 7.5 (central Tasmania), only Eden (6.7) and Barrington (7.8) being outside this range. The only significant differences were between Eden and most other populations (all but Central Coast;  $\bar{x}s = 7.2-7.8$ ), and between Barrington vs Eden and Central Coast vs the Blue Mountains (7.2).

Upper palpebrals: ANOVA:  $F_{9,172} = 3.243^{**}$ . Means ranged from 7.3 (Alps) to 8.8 (Barrington, Central Coast), with the only significant differences between the alpine population vs Central Coast and Blue Mountains (8.2).

Lower palpebrals: ANOVA:  $F_{9,171} = 9.022^{***}$ . Means for all but the alpine population (8.1) were in the range 9.1 (central Tasmania) to 10.5 (Barrington, Central Coast). Significant differences were detected between the alpine population and other mainland populations, together with north-east and south-east Tasmania ( $\bar{x}s = 9.3-10.5$ ), and between Central Coast and all four Tasmanian populations ( $\bar{x}s = 9.1-9.9$ ).

Midbody scales: ANOVA:  $F_{9,213} = 19.296^{***}$ . Means for all but the alpine population (25.0) were in the range 22.4 (north-east Tasmania, Central Coast, Blue Mountains, Eden) to 23.7 (south-east Tasmania). The alpine mean was significantly different to all other populations. Significant differences were also detected in most possible pairwise comparisons between two groups: north-east/highland/south-east Tasmania ( $\bar{x}s = 23.3-23.7$ ) and Central Coast/Blue Mountains/Illawarra/Eden/north-west Tasmania ( $\bar{x}s = 22.4-22.5$ ), only the Eden comparisons with north-east and central Tasmania being non-significant.

Paravertebral scales: ANOVA:  $F_{9,211} = 15.442^{***}$ . Two main groups of populations were apparent. Most mainland populations (Barrington, Central Coast, Blue Mountains, Illawarra) had high means ( $\bar{x}s = 70.9-73.4$ ), while the four Tasmanian populations had low means ( $\bar{x}s = 65.9-67.5$ ). All sixteen possible pairwise comparisons of populations between these two groups were significant. The alpine (68.9) and Eden (69.5) means were intermediate between these two groups, with the alpine mean significantly different to the Central Coast (72.3) and Blue Mountains (72.4) means.

Subcaudal scales: ANOVA:  $F_{9,125} = 206.210^{***}$ . Three groups of populations were apparent. The alpine population had a mean of 53.1 and a range of 48-57, the four Tasmanian populations had means of 73.5-79.5 and an overall range of 68-84, and the five non-alpine mainland populations had means of 89.5-99.1 and an overall range of 83-108. Significant

differences were detected between all possible combinations of population means between these groups, but only between Barrington (89.5) vs Central Coast (99.1) and Blue Mountains (97.6), and between north-east (79.5) vs central Tasmania (73.5) within these groups. On the mainland, the low mean for the Barrington population was the result of a low value for the sole New England animal (83), with the only value available for the true Barrington animals being 96.

The New England locality, six miles north-north-west Ben Lomond, is potentially mistakeable for a mountain of the same name in Tasmania, within the known range of the Tasmanian population (e.g., QVM 1972.3.188). Such a mistake would explain the low subcaudal scale count for the New England specimen. However, the specimen is recorded as collected by G. Webb and J. Parmenter, at the time based at the University of New England, with the same collectors recorded as collecting material of several non-Tasmanian reptile species on the same date from nearby localities. On this basis, I consider the record valid.

Subdigital lamellae: ANOVA:  $F_{9,405} = 17.403^{***}$ . Populations from the middle of the range had low means (Illawarra, Eden, Alps, north-east Tasmania;  $\bar{x}s = 10.1-10.7$ ), significantly different to most populations to the north and south (all vs Central Coast, Blue Mountains, north-west and south-east Tasmania,  $\bar{x}s = 11.5-11.9$ ; Alps also vs Barrington, central Tasmania,  $\bar{x}s = 11.2-11.5$ ).

Snout-vent length: There were no significant differences for either males or females in adult SVL between Tasmanian and mainland Australian material other than the Australian Alps population. Females of the alpine population were significantly smaller than either the Tasmanian (Mann-Whitney U test,  $z = 4.879^{***}$ ) or other mainland groups (Mann-Whitney U test,  $z = 4.752^{***}$ ). Too few males of the alpine population were available to assess the extent of any differences for that sex.

Axilla-groin length: ANOVA:  $F_{9,226} = 13.470^{***}$ . The Tasmanian populations had generally shorter bodies than mainland populations. Significant differences were detected between north-east and south-east Tasmania vs all mainland populations, central Tasmania vs Central Coast, Blue Mountains, Illawarra and Eden, and north-west Tasmania vs Eden.

Tail length: ANOVA:  $F_{9,125} = 52.190^{***}$ . Variation was similar to that in subcaudal scales, with three groups of populations: Tasmania, Australian Alps and other mainland populations. The alpine population, with a very short tail, was significantly different to all other populations, while the four Tasmanian populations had significantly shorter tails than all other mainland populations except Barrington (represented by only two values, one the New England record discussed above).

Forelimb length: ANOVA:  $F_{9,225} = 22.575^{***}$ . In general the Tasmanian populations had long forelimbs, significantly different to all mainland

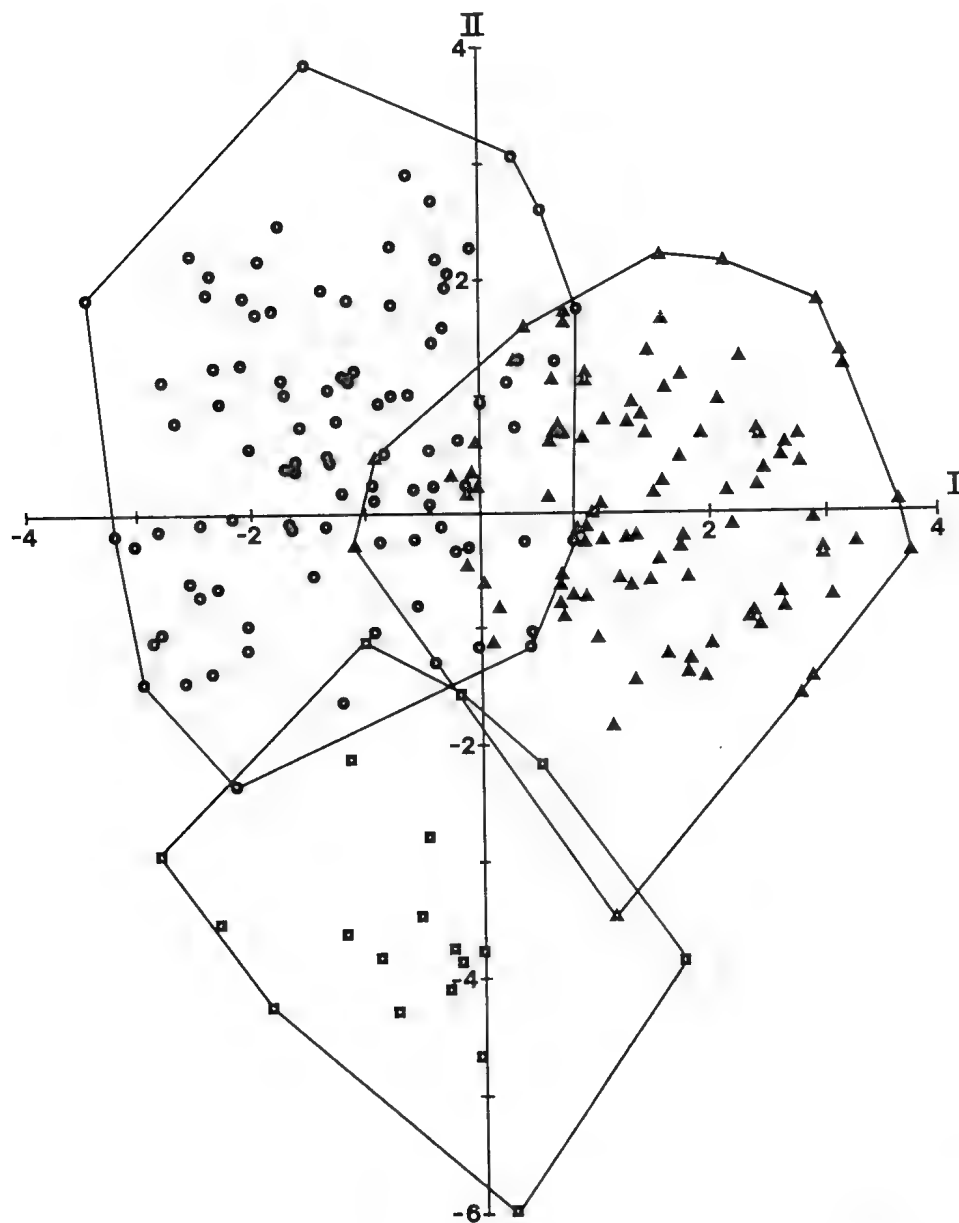


Fig. 3. Ordination of members of the *C. casuarinae* complex on the first two discriminant functions. Dots are *C. michaeli*, triangles are *C. casuarinae*, squares are *C. praealtus*.

populations other than Barrington (in all comparisons) and Central Coast (in the case of north-west Tasmania). The Eden population had significantly shorter forelimbs than all other populations.

Hindlimb length: ANOVA:  $F_{9,216} = 18.108^{***}$ . The pattern of geographic variation was almost identical to that of forelimb length, although Eden was not significantly different to the alpine population and Central Coast was not significantly different to north-east Tasmania but was significantly different to north-west Tasmania.

Head length: ANOVA:  $F_{9,226} = 19.107^{***}$ . In general, Tasmanian populations had proportionally longer heads than mainland populations, with significant differences between south-east Tasmania and all mainland populations, north-east and central Tasmania vs all mainland populations except Barrington, and north-west Tasmania vs Eden. Within Tasmania, there were significant differences between north-west Tasmania (short) vs north-east and south-east Tasmania (long). Amongst mainland populations the only significant difference was between Central Coast (long) and Eden (short).

Head width: ANOVA:  $F_{9,217} = 13.130^{***}$ . In general, Tasmanian populations had broader heads than mainland populations, with significant differences between north-east and south-east Tasmania vs all mainland populations but Barrington, central Tasmania vs all mainland populations but Barrington and Australian Alps, and north-west Tasmania vs Eden.

Canonical variates analysis: A combination of 16 characters (SVL, AGL, FLL, HLL, HL, HW, nasals, prefrontals, presuboculars, postsuboculars, supraciliaries, infralabials, nuchals, midbody scales, paravertebral scales, subdigital lamellae) was used in this analysis.

Overall, the combination of the six significant functions extracted gave reasonable assignment of animals to populations (Table 1), with 67.5% of animals correctly identified (population range 55.0–100.0%). Standardised canonical coefficients and character correlations with canonical functions for the six functions are presented in Table 2. The first two functions identified the same three geographic groups of populations as were identified on number of subcaudal scales and tail length (Fig. 3): Tasmania, Australian Alps and non-alpine mainland Australia.

These two functions alone resulted in correct geographic group identification of 77.3% of Tasmanian animals, 84.2% of alpine animals and 69.8% of other mainland animals. When all functions were considered, the proportion of correct group assignment rose to 91.8% for the Tasmanian group and 90.6% for non-alpine mainland animals, and 88.9% overall. Of the 20 animals incorrectly identified to group, 12 had original tails and could be unequivocally identified to the correct group on subcaudal counts, while an additional four animals had the next greatest probability in the canonical analysis of correct group identification (to the correct population in three cases).

## Discussion

The identification of the same three groups of populations by multivariate analysis as were found by an independently analysed character (number of subcaudal scales), and the geographic cohesiveness of these three groups lead me to recognise these three groups as taxonomically distinct. In the absence of sympatry to test for reproductive isolation, I use the almost complete lack of overlap between these three taxa in number of subcaudal scales (the most geographically remote record of the non-alpine mainland taxon had the only value overlapping with the Tasmanian range, while the alpine taxon did not overlap with either other taxon) to identify them as distinct species under the evolutionary species concept (Frost & Hillis, 1990).

Of the three species, the name *Cyclodomorphus casuarinae* is available for the Tasmanian species and the name *Cyclodomorphus michaeli* is available for the non-alpine mainland taxon, while no name is available for the alpine species, described as new below.

## Systematics

The three species in the *C. casuarinae* complex may be differentiated from the other species of *Cyclodomorphus* by the following combinations of characters. Contacting prefrontal shields (plesiomorphic) and absence of a postnarial groove (apomorphic) differentiate it from the *C. branchialis* species group, while the postmental usually contacting two infralabials on each side (plesiomorphic) and 26 or fewer midbody scales and 14 or fewer subdigital lamellae (apomorphic) distinguish it from *C. gerrardii*. However, in that the absence of a postnarial groove is shared with *C. gerrardii*, while the latter two apomorphies are shared with the *C. branchialis* species group, it is likely that one or more of the apomorphies represent reversals or convergences.

Unless otherwise noted, the following scalational characters of taxonomic importance in skinks were invariant in the *C. casuarinae* complex: supranasals, postnasals and postnarial groove absent; frontal large, longer than wide, broadest rostrally; frontoparietals paired; parietals separated by interparietal (rarely in narrow contact); interparietal broadest rostrally; parietal eye spot present; lower eyelid scaly; primary temporal single; one or more scales intercalated between upper secondary temporal and first pair of nuchals; first pair of chin shields in broad contact; second pair of chin shields separated medially by one scale; third pair of chin shields divided, the two scales on each side separated by three scales; body scales smooth; preanal scales subequal.

### *Cyclodomorphus casuarinae* (Duméril & Bibron, 1839)

*Cyclodus Casuarinae* Duméril & Bibron, 1839: 749. Lectotype: MNHP 7131, Bruny Island, Tasmania (Péron & Lesueur).

*Cyclodus nigricans* Peters, 1875: 621. Holotype: ZMB 8193, Australia (Flower).

*Hemisphaeriodon tasmanicum* Frost & Lucas, 1894: 227. Lectotype: MV D2087, Tasmania (C. Frost).

**Diagnosis.** A moderately large *Cyclodomorphus* (maximum SVL 174 mm), differing from all other species in the genus in the combination of prefrontals usually contacting, postnarial groove absent, postmental usually contacting two infralabials on each side, subcaudal scales 68–84, and dorsal colour pattern often present and complex in adults (dark edges to scales and dark streaks basally and centrally on scales).

**Description.** Nasals usually broadly to narrowly separated (55.6%,  $n = 117$ ), less commonly in point to narrow contact (21.4%) or moderate to broad contact (20.5%), rarely a median internasal present (2.6%); prefrontals usually in moderate to broad contact (55.2%,  $n = 116$ ), less commonly in narrow contact (31.0%), rarely in point contact (1.7%), narrowly to broadly separated (10.3%), or separated by a small median scale

(1.7%); transversely enlarged nuchals 0–6 on each side ( $\bar{x}$  = 2.4,  $sd$  = 1.08,  $n$  = 225), usually three (48.0%) or two (26.2%); loreals two bilaterally; supraoculars usually three bilaterally, rostral two in contact with frontal, second largest (98.3%,  $n$  = 116), rarely two unilaterally (1.7%), reduction due to fusion of first and second supraoculars ( $n$  = 1) or second and third supraoculars ( $n$  = 1); supraciliaries 5–7 ( $\bar{x}$  = 6.0,  $sd$  = 0.29,  $n$  = 232), usually six (91.8%); presuboculars 1–3, usually two (82.2%,  $n$  = 231), rarely one (0.4%); postsuboculars 2–5 ( $\bar{x}$  = 3.6,  $sd$  = 0.56,  $n$  = 231), usually four (55.4%); upper palpebrals 7–12 ( $\bar{x}$  = 8.2,  $sd$  = 1.00,  $n$  = 69); lower palpebrals 7–12 ( $\bar{x}$  = 9.3,  $sd$  = 0.95,  $n$  = 68); secondary temporals usually in  $\alpha$ -configuration bilaterally, rarely in  $\beta$ -configuration unilaterally ( $n$  = 2) or bilaterally ( $n$  = 1); supralabials 6–8 ( $\bar{x}$  = 7.0,  $sd$  = 0.30,  $n$  = 232), usually seven (90.9%), third-last below centre of eye, separating pre- and postsuboculars; infralabials 6–9 ( $\bar{x}$  = 7.4,  $sd$  = 0.56,  $n$  = 227), usually seven (56.4%) or eight (40.1%); usually first two infralabials contacting postmental ( $n$  = 110), rarely one only unilaterally ( $n$  = 4) or bilaterally ( $n$  = 1); ear small, usually with a single small lobule along rostral margin (81.2%,  $n$  = 218), rarely two (6.4%) or lobules absent (12.4%).

Body scales in 22–26 ( $\bar{x}$  = 23.3,  $sd$  = 1.00,  $n$  = 108) longitudinal rows at midbody; scales in paravertebral rows not or only slightly broader than adjacent scales, 61–73 ( $\bar{x}$  = 66.7,  $sd$  = 2.87,  $n$  = 107); subcaudal scales 68–84 ( $\bar{x}$  = 76.9,  $sd$  = 3.89,  $n$  = 69); lamellae below fourth toe 9–14 ( $\bar{x}$  = 11.5,  $sd$  = 1.03,  $n$  = 201).

SVL 41.5–174 mm ( $n$  = 114); AGL/SVL 51.8–69.1% ( $\bar{x}$  = 62.0%,  $n$  = 112); TL/SVL 63.6–133.6% ( $\bar{x}$  = 103.9%,  $n$  = 70); FLL/SVL 12.7–21.4% ( $\bar{x}$  = 15.8%,  $n$  = 114); HLL/SVL 17.5–26.2% ( $\bar{x}$  = 21.5%,  $n$  = 114); FLL/HLL 64.2–85.7% ( $\bar{x}$  = 73.6%,  $n$  = 115); HL/SVL 13.6–24.6% ( $\bar{x}$  = 17.2%,  $n$  = 113); HW/HL 57.9–75.2% ( $\bar{x}$  = 67.9%,  $n$  = 113); HD/HL 40.4–61.1% ( $\bar{x}$  = 50.8%,  $n$  = 112).

#### Coloration (in preservative). Adult coloration variable.

Dorsal ground colour olive-grey to green, rarely reddish. Rarely immaculate, usually with narrow to broad dark brown or black lateral margins to most dorsal body and tail scales, giving solid to broken narrow dark stripes on body and at least tail base. Many individuals also with multiple fine mid brown-grey or russet streaks basally and centrally on most scales, which may in extreme development obscure the dark stripes and ground colour. Some individuals with a few dorsal body and tail scales also dark brown to black edged apically, in rare extreme development leading to irregularly defined narrow dark bands across back and tail.

Head dorsum usually immaculate, but in some strongly patterned individuals with dark flecks or spots along margins of some head shields.

Laterally, body and tail with dorsal ground colour and predominantly striped pattern grading evenly into ventral colour and predominantly banded pattern.

Face olive-grey or green, sutures black edged, espe-

cially subocular supralabials and less commonly other circumocular scalation, giving a dark mask about eyes.

Venter olive-green to blue-grey, rarely immaculate, usually with scattered scales black, especially along apical and lateral margins, sometimes with cream bases, aligned to give a series of narrow dark bands, usually in the form of irregular vermiculations on the body, more regular and on alternate scale rows on tail. Throat variably patterned, from immaculate through a few scattered dark flecks or spots, to three or four solid narrow dark bands cranial to level of forelimbs.

Limbs above with dorsal ground, ventrally with ventral ground, with varying development of dark markings corresponding to dorsal and ventral patterns.

Soles and palms yellow, occasionally with light brown calli or low tubercles.

Rare individuals entirely melanistic, or in one case (MV D11218) with dorsal pattern and ground colour largely obscured by broad, black, nearly confluent bands.

Juveniles with red to olive-green dorsal ground, body dorsum with dark scales and/or scale margins tending to align transversely to give narrow, closely spaced dark bands on body and at least tail base. Nape with two similar but broader and more pronounced dark bands, the more cranial extending rostroventrolaterally towards ears, continuing below ears as one or two narrower bars. Head dorsum of neonates often with a dark brown wash, especially over parietal shields. Subocular supralabial and usually some adjacent circumocular shields solid black, giving a black mask over eyes. Coloration otherwise as adults. Dark nape bands are the most long-lasting element of juvenile coloration, but rarely persist as solid elements beyond SVL 50 mm.

**Coloration (in life).** Three lizards (AM R65206–08) had a faint lavender tint to the sides of the body, the smallest individual having the throat and body and tail venter yellowish-brown (A. Greer field notes). An individual from Mount Wellington (Fig. 4) had the pale parts of the body venter and flanks yellow, the iris mid-brown and the tongue dark blue-black.

**Allometry** (Table 3). With respect to SVL, AGL and TL show positive allometry, while HL and limb lengths show negative allometry. With respect to HLL, FLL shows negative allometry, while HD shows negative allometry with respect to HL.

**Sexual dimorphism.** No significant differences were detected in the degree of separation/contact of nasals or prefrontals, or in mean number of nuchals, presuboculars, postsuboculars, supraciliaries, lower palpebrals, supralabials, infralabials, midbody scales, subcaudal scales or subdigital lamellae ( $t$ -tests). Significant differences were detected between males and females in mean number of upper palpebrals (males:  $\bar{x}$  = 7.9,  $sd$  = 0.60,  $n$  = 25; females:  $\bar{x}$  = 8.4,  $sd$  = 1.10,  $n$  = 42;  $t_{65}$  = 2.06\*) and paravertebral scales (males:  $\bar{x}$  = 65.4,  $sd$  = 2.51,  $n$  = 33; females:  $\bar{x}$  = 67.5,  $sd$  = 2.90,  $n$  = 57;  $t_{88}$  = 3.44\*\*\*).





Fig. 4. A live *C. casuarinae* from Mt Wellington, Tasmania.

Mature females (SVL 103–174 mm;  $\bar{x}$  = 127.6 mm,  $sd$  = 16.97,  $n$  = 48) were much larger than mature males (85–126 mm,  $\bar{x}$  = 107.8 mm,  $sd$  = 12.48,  $n$  = 21; Mann-Whitney U test,  $z$  = 4.416\*\*\*).

Females have significantly longer bodies, shorter tails and legs and shorter but broader heads than males, although the differences in proportions are slight in most characters (Table 4).

**Distribution.** Northern, central and eastern Tasmania, from sea level to the central plateau (Fig. 2). Also Betsy (Green & Rainbird, 1993), Bruny, Maria and Tasman Islands on the east coast. Although there are no specimen-based records from the south-west of Tasmania, sight records exist for Mount Anne and Mount Melaleuca (A. Dudley, M. Hutchinson, pers. comm.).

**Type material.** *Cyclodus casuarinae* was described by Duméril & Bibron (1839) mostly from a single MNHP specimen from Nouvelle Hollande. A second specimen, in the collection of the Zoological Society of London, is mentioned in their description of coloration. Duméril and Bibron did not specifically designate a holotype. However, the Paris specimen (MNHP 7131) has consistently been considered the holotype (Duméril & Duméril, 1851; Guibé, 1954; Brygoo,

1985; Cogger *et al.*, 1983), and must therefore be considered to be lectotype, nominated by assumption of holotype status (Article 74b of the Code of Zoological Nomenclature). The lectotype has been subsequently identified as collected by Péron and Lesueur from Bruny Island during the Baudin Expedition of 1801–04 (Duméril & Duméril, 1851; Guibé, 1954; Brygoo, 1985). This specimen is presumably one of the “quelques beaux lézards analogues aux Scinques, différant toutefois essentiellement des animaux de celle famille par l'élégance des formes et le rapport des proportions” observed by Péron (1807) on Bruny Island between mid January and early February 1802 (see also MacFarlane & Triebel, 1937, for a reprint of Péron's account). The whereabouts of the Zoological Society of London paralectotype are unknown. That collection was largely dispersed to other national and provincial collections in 1852, and the remaining specimens disposed of in 1856 (Sclater, 1901).

The lectotype of *C. casuarinae* (Fig. 5) has the following combination of character states: nasals narrowly separated; prefrontals in narrow contact; supraoculars three; presuboculars two; postsuboculars three; supraciliaries six; supralabials seven; infralabials 7/8, first two contacting postmental; nuchals three;





Fig. 5. Lectotype of *Cyclodus casuarinae* Duméril & Bibron, 1839 (MNHP 7131).



Fig. 6. Holotype of *Cyclodus nigricans* Peters, 1875 (ZMB 8193).

temporals in  $\alpha$ -configuration; midbody scales 24; paravertebral scales 68; tail regenerated from 12th subcaudal; subdigital lamellae 14/13; SVL 145 mm; AGL 95.5 mm; TL 25.5 mm (original part) + 28 mm (regenerate); FLL 20 mm; HLL 26 mm; HL 21.2 mm; HW 15.2 mm; HD 11.1 mm. Although the specimen has been eviscerated, the large size suggests that it was female. Most of the measurements and scalational characters are in close agreement with those given in the type description, only the tail length (62 mm vs 53.5 mm) being noticeably different.

While the type description does not give a precise locality for the lectotype and the regenerated tail precludes use of subcaudal counts to accurately assign it to a population, the more precise locality given by Duméril & Duméril (1851) and subsequent authors, based on MNHP catalogue data, is sufficient to assign the name to the Tasmanian taxon.

The description of *Cyclodus (Homolepida) nigricans* by Peters (1875) is brief, mentioning only the dark coloration, 7/6 supralabials, two loreals longer than high, 25 midbody scales, and 70 scales along the body between lower jaw and vent. Peters considered that the combination of these features and a long snout differentiated his species from *C. casuarinae*, although he gave no comparative data for the latter species. *Cyclodus nigricans* was placed in the synonymy of *C. casuarinae* by Boulenger (1887).

Peters did not give any locality for his species, nor did he explicitly indicate the extent of his type series or its provenance or repository. Although he states at the end of the description that he found additional specimens of the species in collections sent to him by Prof. Flower of the Royal College of Surgeons in London, it is clear from the single set of scale counts and the asymmetry reported in supralabial scales (seven left, six right) that he described his species from only a single specimen. A single specimen (ZMB 8193; Australia; pre: Flower) is identified as the type in Berlin, and in coloration and the direction of asymmetry of the supralabial shields agrees with Peters' description, although Peters counts one fewer supralabial and 25 midbody scales rather than the 24 that I count. The holotype of *C. nigricans* (Figs 6, 7) has the following combination of character states: nasals in moderate contact; prefrontals in moderate contact; supraoculars three; presuboculars two; postsuboculars 3/4; supraciliaries 6/7; supralabials 8/7; infralabials 8/9, first two contacting postmental; rostral ear lobules one; nuchals three; temporals in  $\alpha$ -configuration; upper and lower palpebrals nine; midbody scales 24; paravertebral scales 67; tail regenerated from 34th subcaudal; subdigital lamellae 13; SVL 148 mm; AGL 97 mm; FLL 21 mm; HLL 30 mm; HL 22.9 mm; HW 16.3 mm; HD 11.7 mm. The coloration is uniformly dark brown/black dorsally and dark but with evidence of darker macules centrally on scales ventrally. Although the gonads have not been examined to confirm the sex, the large size of the specimen suggests that it is female. As with *C. casuarinae*, the regenerated tail of this specimen precludes use of

the sole completely diagnostic character to assign the name to this species. However, the canonical variates analysis (Fig. 3) unequivocally (98.9% probability) identifies the type as Tasmanian (67.6% probability of being from south-east Tasmania). Further, I am aware of two other individuals with uniformly dark coloration, both from Tasmania (A. Dudley, pers. comm.).

*Hemisphaeriodon tasmanicum* was described by Frost & Lucas (1894) from material collected by Baldwin Spencer from Lake St Clair. They initially only compared their species with *Cyclodomorphus gerrardii* (then in the monotypic genus *Hemisphaeriodon*), but later (Lucas & Frost, 1896), after examining additional material, recognised its affinities with *C. casuarinae* and placed their species in its synonymy.

Although Frost and Lucas did not indicate the number of specimens on which their description was based, it is clear from the variation expressed ("one to four pairs of nuchals", ventral surface "greyish or brownish") that more than one individual was involved. This is further borne out by their later (Lucas & Frost, 1896) mention of "specimens" from Lake St Clair. No indication was given of the repository of their material, and no types were located by Cogger *et al.* (1983). Amongst the material examined for this paper are five MV specimens from Frost's collection (D2087–90, D2092, Tasmania, received 12 October, 1915, but not registered until 23 June, 1943; A.J. Coventry, pers. comm.) and a single AM specimen (R4142) from Lake St Clair, collected by Spencer and donated by Lucas. The AM animal forms part of a collection from Lucas that includes a syntype of *Ablepharus rhodonoides*, described by Lucas & Frost (1896) in the same paper that synonymised *H. tasmanicum*. Frost & Lucas (1894) placed *tasmanicum* in *Hemisphaeriodon* on the basis of enlarged maxillary teeth, while Lucas & Frost (1896) synonymised it partly on palatal osteology. The mouths of both R4142 and D2087 have been opened subsequent to preservation, in the former case by fracturing the mandibles, in the latter by transecting the adductor musculature, and the palatal mucosa has been stripped back, allowing access to the palatal elements. Both specimens are similar in coloration and in position and condition of preservation. The measurements and scalation of D2087 are very close to those presented by Frost & Lucas (1894), only the midbody count (24) being outside the variation given in the description (26). However, counts of 26 midbody scales are very rare in *C. casuarinae* (only seen in two of 108 specimens examined) and it is possible that the count provided by Frost and Lucas is erroneous. On the basis of collection data and the dissection of the oral cavity, I believe that AM R4142 is certainly a syntype, and on the basis of the similarity between this specimen and D2087, and between the latter and the type description, that MV D2087 is also a syntype. Of the other four MV specimens from Frost's collection, three (D2088–89, D2092) are strongly patterned, and cannot be syntypes (Frost and Lucas emphasised the unpatterned dorsum of their species). The other specimen, D2090, while unpatterned, has been more neatly set, is in a

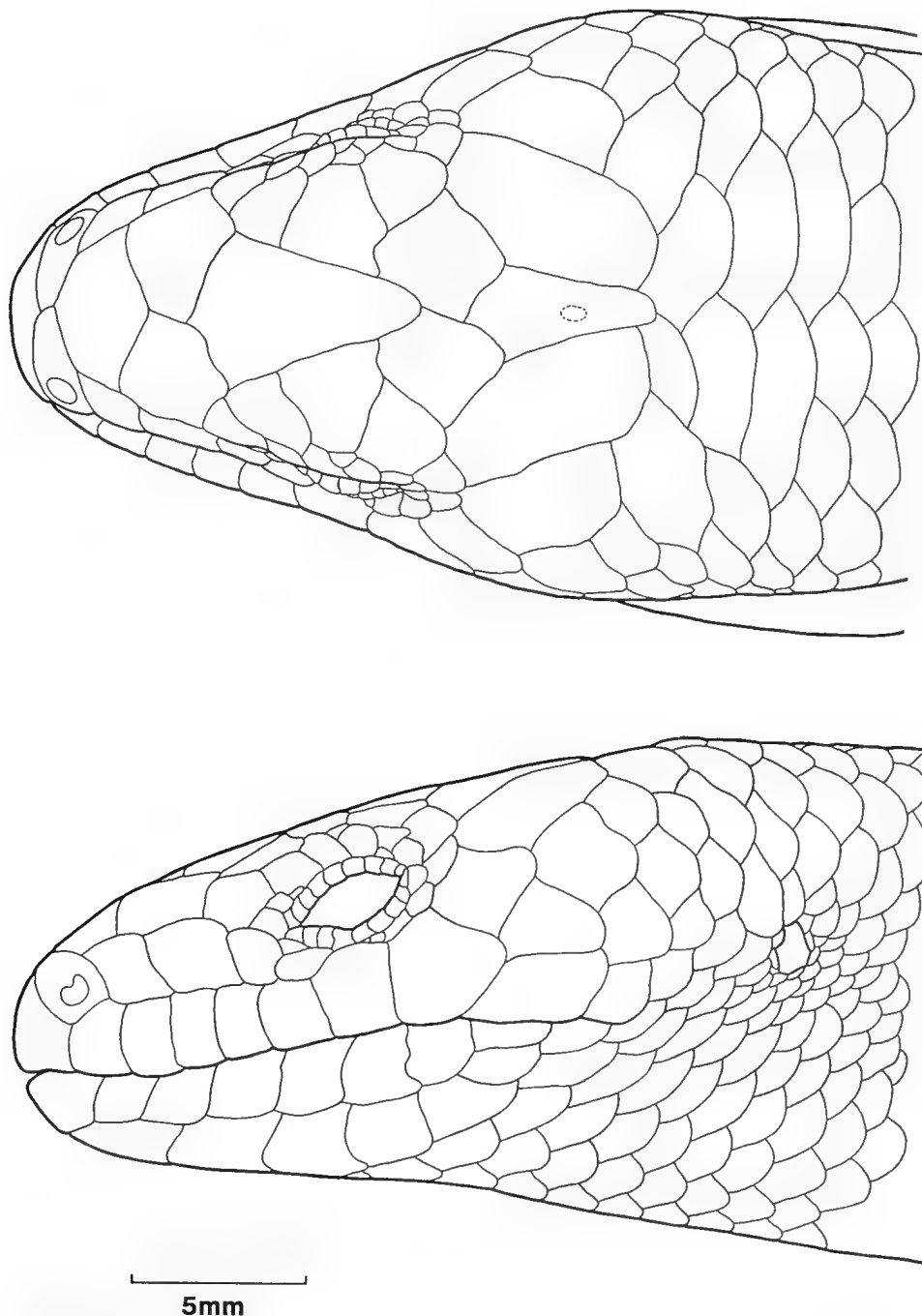


Fig. 7. Dorsal and lateral views of head shields of holotype of *Cyclodus nigricans*.

much better state of preservation, and has clearly been treated very differently to the two identifiable syntypes.

Because of its closer correspondence to the measurements provided by Frost & Lucas (1894), I nominate MV D2087 as lectotype, leaving AM R4142 the only identifiable paralectotype.

The lectotype of *H. tasmanicum* (Figs 8, 9) has the following combination of character states: nasals separated; prefrontals in narrow contact; supraoculars three; presuboculars two; postsuboculars four; supraciliaries

six; supralabials six; infralabials seven, first two contacting postmental; nuchals three; upper palpebrals eight; lower palpebrals nine; temporals in  $\alpha$ -configuration; midbody scales 24; paravertebral scales 62; subcaudal scales 71; subdigital lamellae 11/10; SVL 101 mm; AGL 63 mm; TL 101 mm; FLL 17 mm; HLL 22.5 mm; HL 15.9 mm; HW 11.9 mm; HD 7.6 mm. Both the type locality (Lake St Clair) and the morphology of the two type specimens clearly identify the name as belonging to the Tasmanian taxon.

**Habitat and habits.** Rawlinson (1974) describes *C. casuarinae* as terrestrial, commonest in clearings bordered or surrounded by dense arboreal vegetation, and using exposed patches of low vegetation or litter for basking sites and microenvironments under fallen logs and in deep litter for periods of inactivity. In his tabulation of habitat preferences (Rawlinson, 1974, table 11.5) he records the species from savanna woodland, dry sclerophyll forest and wet sclerophyll forest.

Three more general publications give probably composite accounts of the ecology of members of the *C. casuarinae* complex, although the authors of all three have had some experience with the Tasmanian species. Wilson & Knowles (1988) describe the species as crepuscular to nocturnal, sheltering in grass tussocks and beneath leaf-litter, logs and surface debris in dry sclerophyll forest, woodlands, heathlands and swamplands, particularly where ground cover is dominated by tussock grasses. Ehmann (1992) records the species from "coastal plains, dunes, river flats, valleys and ranges. Vegetation of forests, woodlands, heathlands and tussock grasslands. In relatively closed vegetation structures, the species inhabits clearings, edges and other natural canopy openings that are invaded by dense low ground cover, especially spreading tussock grass." The species "shelters under embedded fallen logs, deep litter, stones and the procumbent spreading apron around the base of large tussock grasses and low bushes. It forages during the day and on warm nights, stalking and ambushing insects, snails, grubs and small lizards under partial cover." Cogger (1986) reports the species from a wide variety of habitats, from "coastal heaths and sand dunes to the dry sclerophyll forests of the ranges. Common in coastal grazing lands. Normally crepuscular to nocturnal, it is usually found during the day in leaf-litter or under fallen timber."

Specific data are available for few specimens. Green (1977) reported the species to be uncommon at his Maggs Mountain study site, with only three records. One adult was collected by a roadside in wet sclerophyll forest. Among the material examined for this study, habitat and microhabitat data are available for AM R65206–08 (under pieces of thin wood/timber which were very dry underneath, on a north-east facing grassy slope with lots of timber and large dead trees scattered about the paddocks; A. Greer field notes), AM R65209–10 (under dry rubbish in a cleared south-facing sloping paddock with rock outcrops, boards, rubbish and tree pieces scattered throughout, below a eucalypt forest; A. Greer field notes) and AM R70069–72 (under sheet iron in grassland bordered by dry sclerophyll forest; G. Stephenson field notes).

For a series of six lizards, Rawlinson (1974) reported a voluntary thermal minimum of 27.1°C, a voluntary thermal maximum of 39°C and a mean active temperature of 32.6°C.

Fleay (1952) reports predation by the Tasmanian Devil, *Sarcophilus harrisii*.

**Reproduction.** Adult females are available only from between October and March (Fig. 10). In this period, females with grossly enlarged ovarian follicles were only present between late October and early December, while oviducal yolks and embryos were present between early November and March. Between January and March, non-gravid females with small ovarian follicles were also collected. The data, being pooled over many years, are insufficient to determine whether the occurrence of both gravid and non-gravid material in summer reflects non-annual reproduction or variation in the timing of parturition. However, I suspect from the occurrence of enlarged ovarian follicles over almost a two month period, the occurrence of fully scaled and pigmented embryos in females collected as early as 19 January (TM C127) and as late as March (QVM 1972.3.17b), and the existence of neonates born January and March (MV D39151–56, SVL 41.5–44.5 mm, born to D39139, collected 31 January, 1967; QVM 1984.3.13b–g, SVL 42.5–45 mm, born after 4 weeks captivity to 1984.3.13a, collected 9 February, 1984; SAM R8784–8785, SVL 42 mm; collected January, 1967) that the latter is the case. Rawlinson (1974) reported parturition in mid to late February.

Mature males have turgid testes throughout the year (Fig. 11). The largest testes were seen in males collected 27 May, 30 September and December. The latter two dates correspond to the inferred timing of ovulation, but the May date is well before this period. Rawlinson (1974) stated that copulation occurs in Spring.

Females (SVL 103–174 mm,  $\bar{x}$  = 127.6,  $sd$  = 16.90,  $n$  = 25) carried from 4–14 ( $\bar{x}$  = 7.6,  $sd$  = 3.06,  $n$  = 26) enlarged yolking ovarian follicles or oviducal yolks or embryos. There was a significant positive correlation between litter size and maternal SVL (litter =  $0.117SVL - 7.219$ ;  $r = 0.655^{***}$ ).

There are several literature reports of litter size for *C. casuarinae*, although in the absence of associated locality data most could refer to any of the three species here recognised. Worrell (1963) reported "about six young", Frauca (1966) a litter of six, Peters (1967) 6–8 young, Bustard (1970) a litter of 19, Swanson (1976) around five young, Wilson & Knowles (1988) 2–17, usually about four, and Ehmann (1992) up to 19, usually about seven. More precise figures are given by Rawlinson (1974), Greer (1989) and Shine & Greer (1991), who give 2–7 ( $\bar{x}$  = 4.1,  $n$  = 15), 4–14 ( $\bar{x}$  = 6.8,  $n$  = 8) and 4–14 ( $\bar{x}$  = 6.87,  $n$  = 8) respectively.

**Sex ratio.** Overall, the ratio of mature males:females was 21:49, significantly different to 1:1 ( $\chi^2_1 = 10.41^{***}$ ), although animals were only available between September and May. Seasonally, there was a significant difference in sex ratio between the gestation period and other months (male:female; November–March, 9:29; April–October, 6:3;  $\chi^2_1 = 6.05^*$ ).

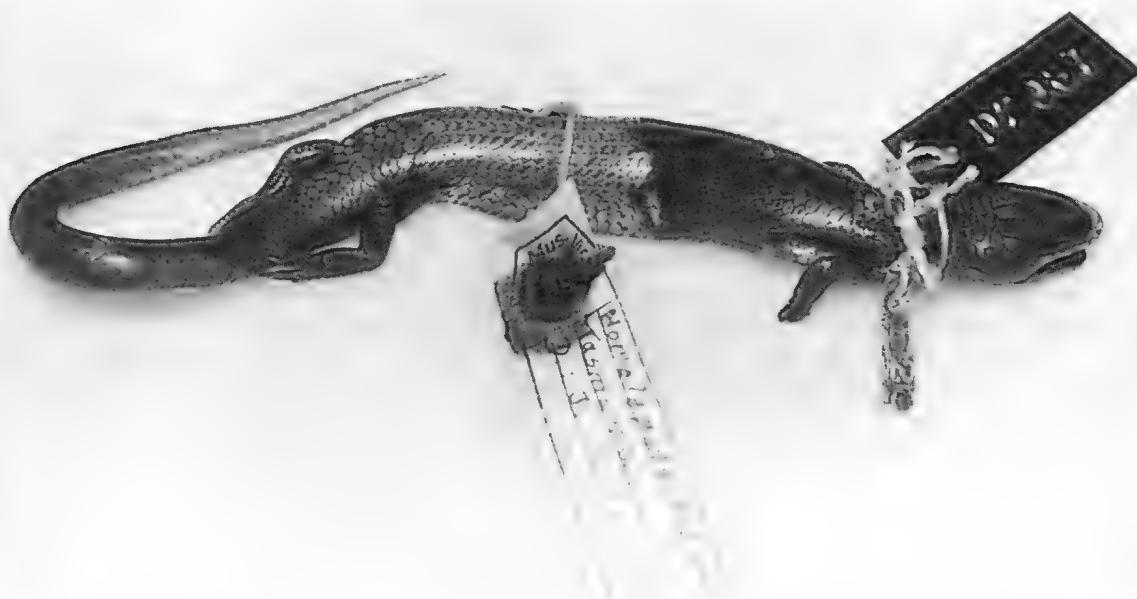


Fig. 8. Lectotype of *Hemisphaeriodon tasmanicum* Frost & Lucas, 1894 (MV D2087).

**Specimens examined.** 1. NORTH-EAST TASMANIA: MV D1051, Scottsdale; D39139, D39151–56, 16 km SSW Scottsdale; QVM 1006, Launceston; 1940.302, Montana; 1942.220, Deloraine; 1943.142, Hill Street, Launceston; 1944.76, Lebrina; 1962.3.28a–b, 1963.3.12–13, Winnaleah; 1969.3.8.a–b, Sideling, Launceston-Scottsdale road; 1972.3.188, south-east slope Ben Lomond; 1981.3.96, North Lilydale; 1984.3.13a–g, Liffey; 1987.3.74, Dairy Plains; TM C48, St Columba Falls, Pyengana. 2. NORTH-WEST TASMANIA: AM R37702–03, Zeehan; R37704–06, 4 miles west Queenstown; MV D915, Emu Bay; D39138, 24 km east Marrawah; D39140, 25 km south-east Zeehan; D39142, 17 km south-west Smithton; D39143, 6.4 km east Queenstown; D39144, Collingwood River, 44 km east Queenstown; QM J41561, Franklin River, below Goodwins Peak; J41562, south side Macquarie Harbour; QVM 1958.3.7, Burnie; 1969.3.13, near Devonport; 1972.3.19, Ulverstone; 1972.3.121, Renison Bell. 3. CENTRAL TASMANIA: AM R4142 (paralectotype of *H. tasmanicum*), Lake St Clair; R65206–08, 17.4 km north Breona via Highway 5; R65209–10, north-east side Bronte Lagoon, just north Lyell Highway; MV D56347–49, Mount Field; D56658, 2.6 km south Bronte Lagoon; NTM R9292, Cradle Mountain; QVM 1962.3.40, Erriba; 1964.3.3, Waratah - Hellyer Spur road; 1972.3.17a–b, Great Lake; 1976.3.22, Maggs Mountain; 1979.3.37, 1979.3.39, Maggs Mountain Hut; SAM R8784–85, south extreme, Lake Sinclair [St Clair]; R8798, Lake Sinclair [St Clair]. 4. SOUTH-EAST TASMANIA: AM 4785, Ouse River; R10053, Catamaran; R68001, Russell Falls National Park; R70069–72, Russell River, 5 km north Judbury in Huon Valley; R107594, Eaglehawk Neck; ANWC R3071, Huon River, 14 km east Judbury; MNHP 7131, Bruny Island (type of *C. casuarinae*); MV D29, Port Arthur; D2593, Port Esperance; D5733–34, Tasman Island; D7919–20, Kingston; D7991, Ridgeway; D11218, Huon Valley; D39128, 9.6 km west Geavestown; D39133, Coal Mines; D39141, 11.3 km south Huonville; D39145, 5.6 km east-south-east Longley; QVM 1972.3.16, Antill Ponds; TM C39, Kettering; C114, Lunawanna, South Bruny Island; C126–27, Lower Longley; C258, Dover; C267a–b, Cygnet; C273, Maria Island; C305, West Moonah; C318,

Counsel Creek, Maria Island; C997, Wellesley Street, South Hobart. UNLOCALISED: AM R2917, no data; R14402, north Tasmania; MV D1611, D2087 (lectotype of *H. tasmanicum*), D2088–90, D2092, D4919, QM J13774, QVM 1950.3.1, SAM R2231, R6131, Tasmania; SAM R59, "South Australia"; ZMB 8193, Australia (type of *C. nigricans*).

*Cyclodomorphus michaeli* Wells & Wellington,  
1984

*Cyclodomorphus michaeli* Wells & Wellington, 1984: 89.  
Holotype: AM R111948, Mount Victoria, NSW (C.R. Wellington) (cited as AM field series 28007 in original description).

**Diagnosis.** A moderately large *Cyclodomorphus* (maximum SVL 174 mm), differing from all other species in the combination of prefrontals usually contacting, postnarial groove absent, postmental usually contacting two infralabials on each side, subcaudal scales 91–108, midbody scales 20–24 (usually 22), supraciliaries modally six and dorsal colour pattern in adults, when present, usually restricted to narrow dark edges to scales.

**Description.** Nasals usually moderately to narrowly separated (49.1%,  $n = 114$ ), less commonly in point to narrow contact (30.7%), or moderate to broad contact (20.2%); prefrontals usually in moderate to broad contact (92.0%,  $n = 113$ ), less commonly in narrow contact (6.2%), rarely in point contact (0.9%) or narrowly separated (0.9%); transversely enlarged nuchals 0–12 on each side ( $\bar{x} = 3.1$ ,  $sd = 1.12$ ,  $n = 225$ ), usually three (62.2%), only two counts of more than six; loreals usually two bilaterally (99.1%,  $n = 114$ ), rarely one

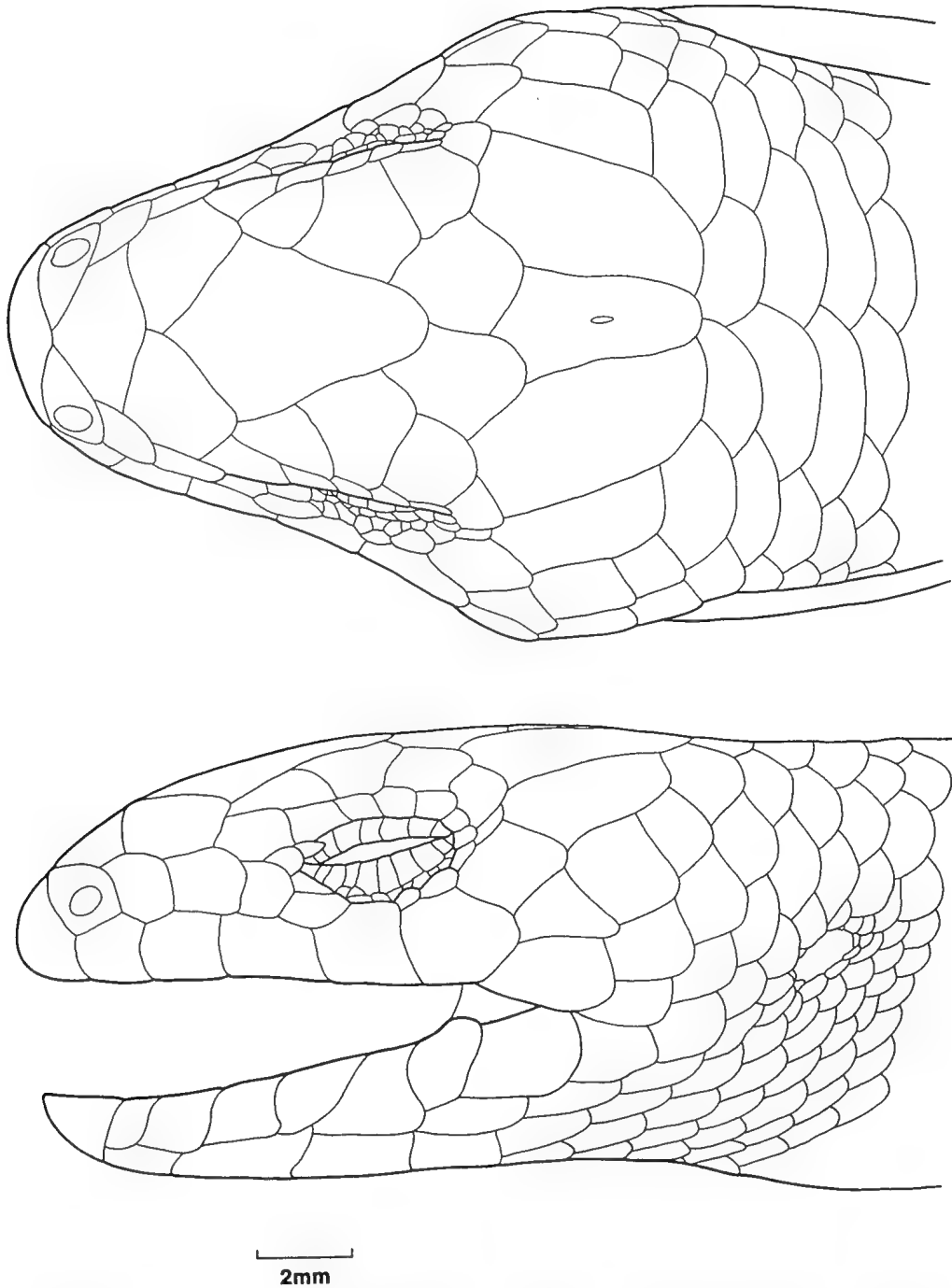


Fig. 9. Dorsal and lateral views of head shields of lectotype of *Hemisphaeriodon tasmanicum*.

bilaterally (0.9%); supraoculars usually three bilaterally, rostral two in contact with frontal, second largest (95.5%,  $n = 112$ ), rarely two unilaterally (2.7%) or bilaterally (1.8%), reduction due to fusion of first and second supraoculars ( $n = 4$ ) or first supraocular and first supraciliary ( $n = 1$ ); supraciliaries 4–7 ( $\bar{x} = 5.8$ ,  $sd = 0.55$ ,  $n = 225$ ), usually six (76.4%); presuboculars 2–3, usually two (79.3%,  $n = 227$ ); postsuboculars 2–5 ( $\bar{x}$

$= 3.4$ ,  $sd = 0.54$ ,  $n = 224$ ), usually three (54.0%); upper palpebrals 6–12 ( $\bar{x} = 8.2$ ,  $sd = 0.98$ ,  $n = 103$ ); lower palpebrals 8–13 ( $\bar{x} = 10.0$ ,  $sd = 1.04$ ,  $n = 104$ ); secondary temporals usually in  $\alpha$ -configuration bilaterally, rarely in  $\beta$ -configuration unilaterally ( $n = 5$ ) or bilaterally ( $n = 1$ ); supralabials 6–8 ( $\bar{x} = 7.0$ ,  $sd = 0.31$ ,  $n = 226$ ), usually seven (90.3%), third-last below centre of eye, separating pre- and postsuboculars; infralabials

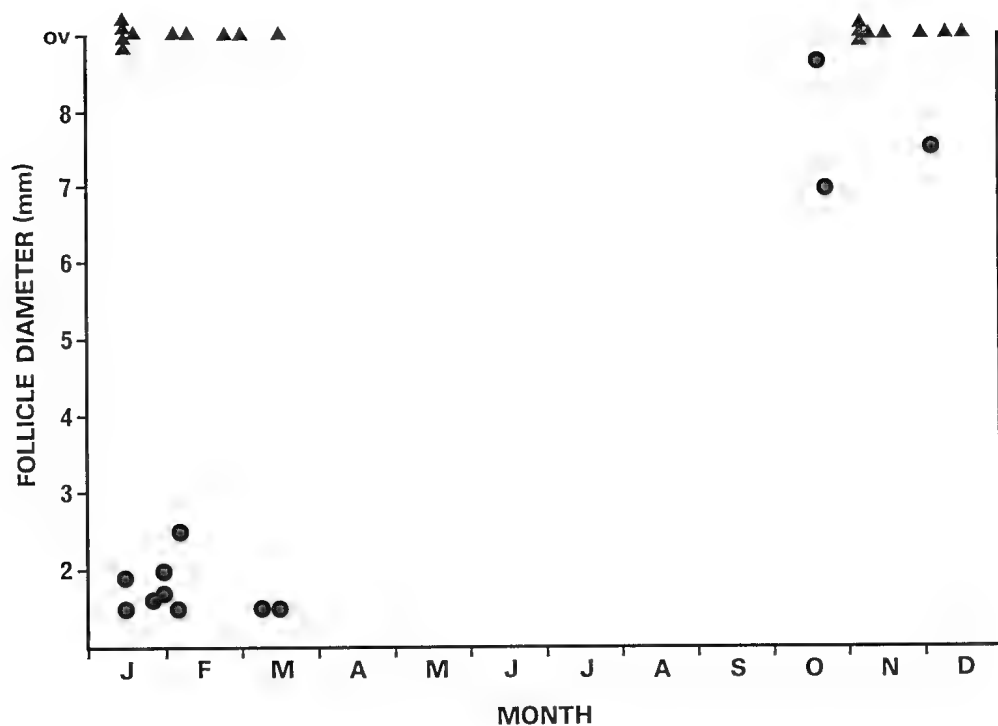


Fig. 10. Seasonal variation in size of largest ovarian follicle, and occurrence of oviducal embryos (ov) in *C. casuarinae*.

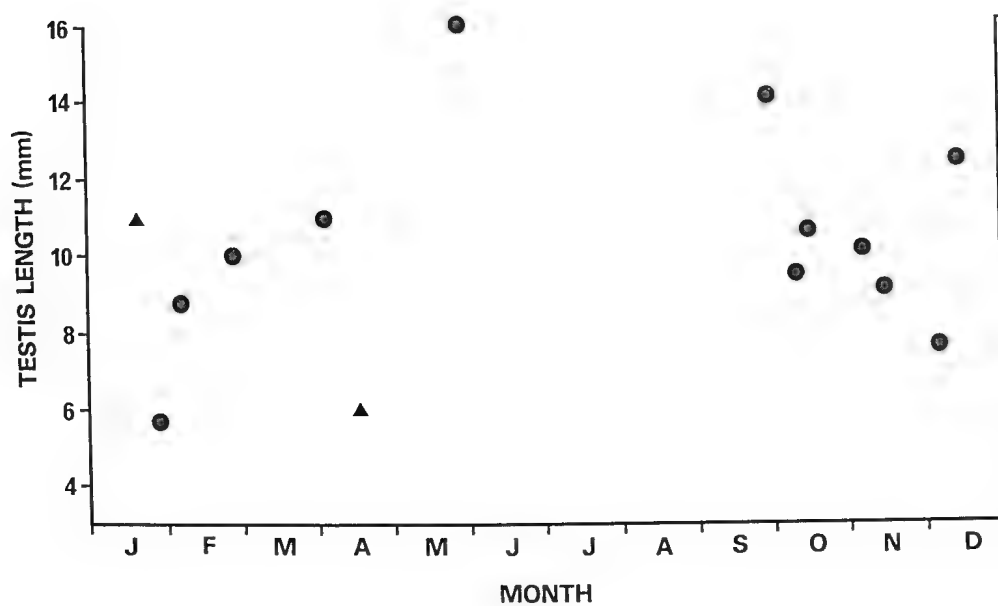


Fig. 11. Seasonal variation in testis length in *C. casuarinae*. Dots are turgid rounded testes, triangles are flaccid or flattened testes.



6–9 ( $\bar{x} = 7.2$ ,  $sd = 0.68$ ,  $n = 225$ ), usually seven (51.6%) or eight (32.8%); usually first two infralabials contacting postmental ( $n = 107$ ), rarely one only unilaterally ( $n = 2$ ) or bilaterally ( $n = 3$ ) or first three unilaterally ( $n = 2$ ); ear small, usually with a single small lobule along rostral margin (82.1%,  $n = 218$ ), rarely lobules absent (17.9%).

Body scales in 20–24 ( $\bar{x} = 22.5$ ,  $sd = 0.91$ ,  $n = 113$ ) longitudinal rows at midbody; scales in paravertebral rows not or only slightly broader than adjacent scales, 62–82 ( $\bar{x} = 71.6$ ,  $sd = 3.57$ ,  $n = 112$ ); subcaudal scales 83–108 ( $\bar{x} = 97.2$ ,  $sd = 4.11$ ,  $n = 56$ ), only one less than 91; lamellae below fourth toe 8–14 ( $\bar{x} = 11.1$ ,  $sd = 1.07$ ,  $n = 210$ ).

SVL 29.5–174 mm ( $n = 111$ ), smallest neonate 39.5 mm; AGL/SVL 50.8–72.8% ( $\bar{x} = 64.5\%$ ,  $n = 111$ ); TL/SVL 78.0–163.6% ( $\bar{x} = 128.5\%$ ,  $n = 54$ ); FLL/SVL 10.8–20.6% ( $\bar{x} = 14.2\%$ ,  $n = 110$ ); HLL/SVL 13.8–24.2% ( $\bar{x} = 19.2\%$ ,  $n = 110$ ); FLL/HLL 62.5–86.7% ( $\bar{x} = 73.6\%$ ,  $n = 111$ ); HL/SVL 12.1–27.5% ( $\bar{x} = 15.8\%$ ,  $n = 111$ ); HW/HL 57.3–79.1% ( $\bar{x} = 66.6\%$ ,  $n = 104$ ); HD/HL 45.0–64.7% ( $\bar{x} = 53.9\%$ ,  $n = 110$ ).

**Coloration (in preservative).** Coloration variable. Adults with dorsal ground colour usually olive green, sometimes red to blue-grey. Dorsal pattern on body and tail usually either absent or limited to narrow dark brown or black lateral edges to individual scales, aligning to give narrow dark stripes, often zigzagging finely due to scale overlap pattern. Dorsum rarely with more extensive dark edges to apical margins of scales, giving a less regular, predominantly narrow-banded pattern. Very rarely a few fine brown streaks basally on scales (e.g., AM R54802), as in *C. casuarinae*.

Head dorsum usually immaculate, rarely, in most strongly patterned individuals, with a few dark flecks or spots aligned along margins of median head shields.

Laterally, body and tail with dorsal ground color and predominantly striped pattern (when present) blending evenly with ventral ground color and predominantly banded pattern (when present). Lateral pattern usually weakly developed.

Face olive green or brown to blue-grey, usually immaculate, sometimes with weak narrow dark edges to some subocular and circumocular head shields, slightly obscuring ocular region.

Venter blue-green to olive yellow-green, occasionally immaculate, more commonly body and tail (but rarely throat) with varying intensities and densities of dark scales, pigmentation especially apically on scales. Markings tend to be transversely aligned into vermiculations on body and narrow dark bands on alternate scale rows of tail.

Limbs with ground color and pattern corresponding to body dorsum and venter, although ventrally usually immaculate or only weakly spotted.

Soles and palms yellow to mid-brown.

Juveniles and some subadults (up to 70 mm SVL) with strong solid dark nape bands, the most cranial often several scales wide, extending rostroventrolaterally to

ears, then continuing below ears as one or two narrower dark bars. Head dorsum often with a dark grey-brown flush, particularly caudally. Circumocular scalation and subocular supralabial black, giving a solid dark vertical bar over eye. Throat often with a few narrow dark bands. Body dorsum of neonates often with apical dark margins to scales pronounced, leading to a dominant pattern of narrow, closely spaced bands dorsally and laterally.

**Coloration (in life).** Timms (1977) records adult and juvenile coloration of animals from the Cooranbong area. An adult had “back and sides... almost uniform olive-brown... most scales had darker edges... a slight yellow tinge under the chin and a definite orange colouration on the belly. The obvious checkerboard pattern (due to every second scale being half white and half black) on the belly gave way to definite stripes underneath the tail. The legs were longitudinally striped. The inside of the mouth and tongue were blue.” Juveniles were either striped or banded (ratio 6:7 in a litter of eleven) with ground colour “grey (which had a yellowish-green tinge for 24 hours post birth) and the blotches and stripes... black. The characteristic large black blotches on the head... extended from the nose to behind the ear with lobes down over the eyes and ears. In the vertically striped [banded] individuals this was followed by a complete stripe, then by numerous thinner stripes, often incomplete, but on the tail they formed complete rings. In the longitudinally striped individuals there were 4–6 narrow black stripes on the back extending down the tail. The [sides] were blotched in incomplete vertical stripes, much the same as those in the previous pattern. The belly scales in both patterns were somewhat transparent.”

Rankin (1973) described juveniles from the Martinsville area with “a broad black band on the nape and another on the neck, while the frontal area of the head is greyish-brown. There is also a vertical black streak through the eye. Between the bands on the nape and neck and around the auricular region is a distinct orange tinge. The body is olive coloured with black edged scales...”

Three animals from five miles east of Nerriga (one AM R75966) showed variation in coloration from deep russet to grey with black checks on dorsum (P. Rankin field notes).

**Allometry** (Table 5). With respect to SVL, AGL and TL show positive allometry, while HL and limb lengths show negative allometry. With respect to HLL, FLL shows negative allometry, while HW shows negative allometry with respect to HL.

**Sexual dimorphism.** No significant differences were detected in the degree of separation/contact of nasals or prefrontals, or in mean number of nuchals, presuboculars, postsuboculars, supraciliaries, upper or lower palpebrals, supralabials, infralabials, midbody scales, subcaudal scales or subdigital lamellae (t-tests). Significant differences were detected between males and females in mean number of paravertebral scales (males:  $\bar{x} = 70.5$ ,  $sd = 3.64$ ,  $n = 51$ ; females:  $\bar{x} = 72.6$ ,  $sd = 3.28$ ,  $n = 47$ ;  $t_{96} = 2.96^{**}$ ).



Fig. 12. A (above) – a live adult *C. michaeli* from Mt Cambewarra, NSW. B (below) – a live juvenile *C. michaeli* from Mt Victoria, NSW.

Mature females (101–174 mm,  $\bar{x}$  = 126.0 mm,  $sd$  = 16.45,  $n$  = 34) were much larger than mature males (73.5–127.5 mm,  $\bar{x}$  = 107.8,  $sd$  = 14.32,  $n$  = 32; Mann-Whitney U test,  $z$  = 4.24\*\*\*).

Females have significantly longer bodies, but shorter tails, legs and heads than males, although the proportional differences are slight in most cases (Table 6).

**Distribution.** Eastern New South Wales and extreme north-eastern Victoria (Fig. 1), from the following six apparently isolated populations: eastern Gippsland, near-coastally from Little Ram Head north to Cape Green and inland to Chandler's Creek; the Illawarra region and southern Sydney, from five miles east Nerriga north to Sydney Harbour (Darlinghurst, Centennial Park, Rose Bay); the Blue Mountains, from Glenbrook, north-west to Mount Victoria and north to Mount Irvine; the central coast and hinterland, from the Hawkesbury River north to 13 km east Raymond Terrace; the Barrington Tops region, and a single record from the New England tableland (six miles north-north-east Ben Lomond).

Additional literature records are for Awabakal Nature Reserve (Parks & Tasoulis, 1984), Martinsville (Rankin, 1973), Tianjara (Slater, 1978), Narrabarba Nature Reserve (Pyke & O'Connor, 1991), the Betka River Rapids in Croajingolong National Park, Link Camp Creek in Croajingolong and Alfred National Parks, and Burglars Gap in Coopracambra State Park (Mansergh & Watson, 1984), although a literature record of "*Tiliqua casuarinae*" from Queensland (Shine, 1984) cannot be confirmed and is presumably in error. Swan (1990) maps two localities just south of the headwaters of the Shoalhaven River, well outside the known range of this taxon. One of these is based on AM R6803 (Inglewood, Colo Vale), which he assumed to be the Inglewood at 35°54'S 149°22'E, very distant from Colo Vale. The other record is based on a sight observation from Braidwood by W. Osborne (G. Swan, pers. comm.).

Also known, but without museum voucher specimens, from the Kanangra Plateau south-west of the Blue Mountains (a single individual from along Whalanian Fire Road, Kanangra Boyd National Park, 33°52'S 150°03'E; S. Blomberg, pers. comm.) and as far north coastally as Tea Gardens (J. Scanlon, pers. comm.).

**Type material.** Wells & Wellington (1984) described *Cyclodomorphus michaeli* from a single specimen from Mount Victoria, NSW, without making any attempt to differentiate it morphologically or genetically from *C. casuarinae*, which they considered to be restricted to Tasmania. Initially, they considered their species to be restricted to "post-glacial montane refugia of New South Wales from the Snowy Mountains to the Hunter River valley", but subsequently (Wells & Wellington, 1985) restricted it to "the Blue Mountains Plateaux", resurrecting *Cyclodus nigricans* from the synonymy of *C. casuarinae* and applying the name to "the population in Victoria and south-eastern New South Wales". Still more recently (Wells, 1988; Wells & Wellington, 1988a,b, 1989) they have reduced their taxon to a subspecies of

*C. casuarinae*, and referred to it individuals from Ourimbah State Forest on the central coast (Wells, 1988) and populations on the south coast from South Head to Helensburgh and on the Woronora and Hornsby Plateaux (Wells & Wellington, 1989). None of the taxonomic and nomenclatural actions made by Wells and Wellington are formally supported by presentation of new data or re-interpretation of existing data.

The validity of the numerous new names and other nomenclatural actions proposed by Wells & Wellington (1984, 1985) has been questioned by several authors (e.g., Cogger, 1986; Australian Society of Herpetologists, 1987; Shea, 1987; Hutchinson & Donnellan, 1992). However, the International Commission on Zoological Nomenclature has refused to make any formal ruling on a petition to suppress the Wells and Wellington works (Anon., 1991). I believe that *Cyclodomorphus michaeli*, like other species described in the first Wells and Wellington publication, is a validly published name for the purposes of the Code of Zoological Nomenclature, and that there is no case for refusing to apply it to the present species. However, it should be noted that although I use their name, I apply it to a species with different limits to that proposed by Wells and Wellington (1984) or any of their subsequent restrictions.

The holotype of *Cyclodomorphus michaeli* (AM R111948; Figs 13, 14) has the following combination of character states: nasals narrowly separated; prefrontals in moderate contact; supraoculars three; presuboculars two; postsuboculars three; supraciliaries six; supralabials 8/7; infralabials seven, first two contacting postmental; rostral ear lobules absent; nuchals 2/3; temporals in  $\alpha$ -configuration; upper palpebrals eight; lower palpebrals nine; midbody scales 22; paravertebral scales 74; subcaudal scales 96; subdigital lamellae 11; SVL 166 mm; AGL 119 mm; TL 216 mm; FLL 18.5 mm; HLL 25.5 mm; HL 20.6 mm; HW 14.0 mm; HD 10.8 mm. While the gonads have not been examined to confirm the sex, the very large size of the specimen indicates that it is female. In several features, the measurements and scale counts I make on this specimen differ from those provided in the type description. Most of these (e.g., postnasal absent, loreals two vs postnasal present, loreal one; supraoculars three, supraciliaries six vs supraoculars four, supraciliaries five; subdigital lamellae 11 vs 14) presumably reflect different operational definitions of various characters, which were not indicated by Wells & Wellington (1984). However, they also identify the tail as regenerated, although radiographs indicate that it is original and complete.

**Habitat and habits.** There are several literature records of habitat for *C. michaeli*. Swan (1990) reports the species from dry sclerophyll forest, coastal grazing lands and sandy heaths, while Slater (1978) reports it from heath. Wells & Wellington (1984) consider that the species occurs "mainly in *Danthonia* tussock grasses of montane forests, but... also... wet sclerophyll and rain-forests of some areas as well as coastal heaths and grasslands. It is largely crepuscular... and is quite



Fig. 13. Holotype of *Cyclodomorphus michaeli* Wells & Wellington, 1984 (AM R111948).

secretive, being more often found beneath objects on grass." In the Hunter River region, Waterhouse (1981) considers the species common in swamp oak forests on the edge of wetlands, where it is often found sheltering beneath loose bark or in swampside grass clumps. At nearby Cooranbong, Timms (1977; see also Cowled, 1974) describes it as inhabiting dry sclerophyll forest, grazing lands, gardens, and *Casuarina* leaf litter in coastal dunes, hiding under logs, stacks of timber and in long grass, and emerging mainly at night. Further south, on the Central Coast, Wells (1988) records an individual under a sheet of bark on grass and sandy soil in dense heath and forest, while juveniles have been found under sheets of ironbark and blocks of wood on the ground (Rankin, 1973). In the Blue Mountains, it has been reported from leaf litter and fallen timber in dry sclerophyll forest, grassy woodland and heath (Smith & Smith, 1990). In the Sydney region, the species has been reported under boards and sheet iron (Mackay, 1949), while at Dapto, Maddocks (in Shea, 1982) found several individuals active and feeding around 2300 hrs on a warm evening in August 1974. In Victoria, MacFarlane *et al.* (1987) record two individuals from under logs in heathland sites, one dominated by *Gahnia*, *Casuarina* and *Comesperma*, the other near a small stand of *Eucalyptus cephalocarpa* in heathland dominated by *Xanthorrhoea* (sic) and *Leptocarpus tenax*.

Habitat and microhabitat data are available for several of the animals examined in this study. Specimens from the Raymond Terrace and Newcastle districts have been found "beneath cardboard on sand and dry grass, 1015–1025 hrs" (AM R54802) and torpid in a short burrow under a rock in dense grassland bordering a swamp (AM R112395).

In the Watagan State Forest (P. Rankin field notes), animals have been found basking on the edge of sheet iron at 0730 hrs (AM R54715), sunning outside a hollow log in long grass at edge of road in wet/dry sclerophyll

forest (AM R68348), under a log in a clearing in wet sclerophyll forest (AM R75956), in curled up bark in a roadside clearing in wet sclerophyll forest (AM R75967) and under bark (AM R76516).

An Ourimbah animal was found in a hole in the ground in wet sclerophyll forest (AM R73287).

In the Sydney region, animals from La Perouse have been found in coastal heath (AM R93762) and under sheets of roofing iron in long grass surrounded by eucalypts and banksias (AM R102945–46).

The specimen from near Nerriga (AM R75966) was found, together with two other individuals, basking or under tin in an open grassy area with basalt rocks (P. Rankin field notes).

A Victorian animal (AM R57875) was found under a flat piece of wood lying in undergrowth among twigs and other litter (S.J. Copland, field notes).

Captive specimens of this species (and possibly other members of the *C. casuarinae* complex) have proven to be aggressive to other lizards and both captive and wild-caught animals readily bite when handled (Peters, 1967; Rankin, 1973; Timms, 1977; see also Swanson, 1976; Swan, 1990).

Predation by the highland copperhead *Austrelaps ramsayi* has been reported by Shine (1987). A record of a sheoak skink from the stomach of a Queensland *Cryptophis nigrescens* (Shine, 1984) cannot be confirmed (R. Shine, pers. comm.) and given the locality is presumably in error.

**Reproduction.** Mature females were available for all months except April and June–September (Fig. 15). Enlarged yolking follicles were present in all three October animals, but not at other times of the year, while oviducal yolks and embryos were present from late November to early January. The data suggest that ovulation occurs in mid/late Spring, gestation takes 2–3 months, and young are born in mid Summer.

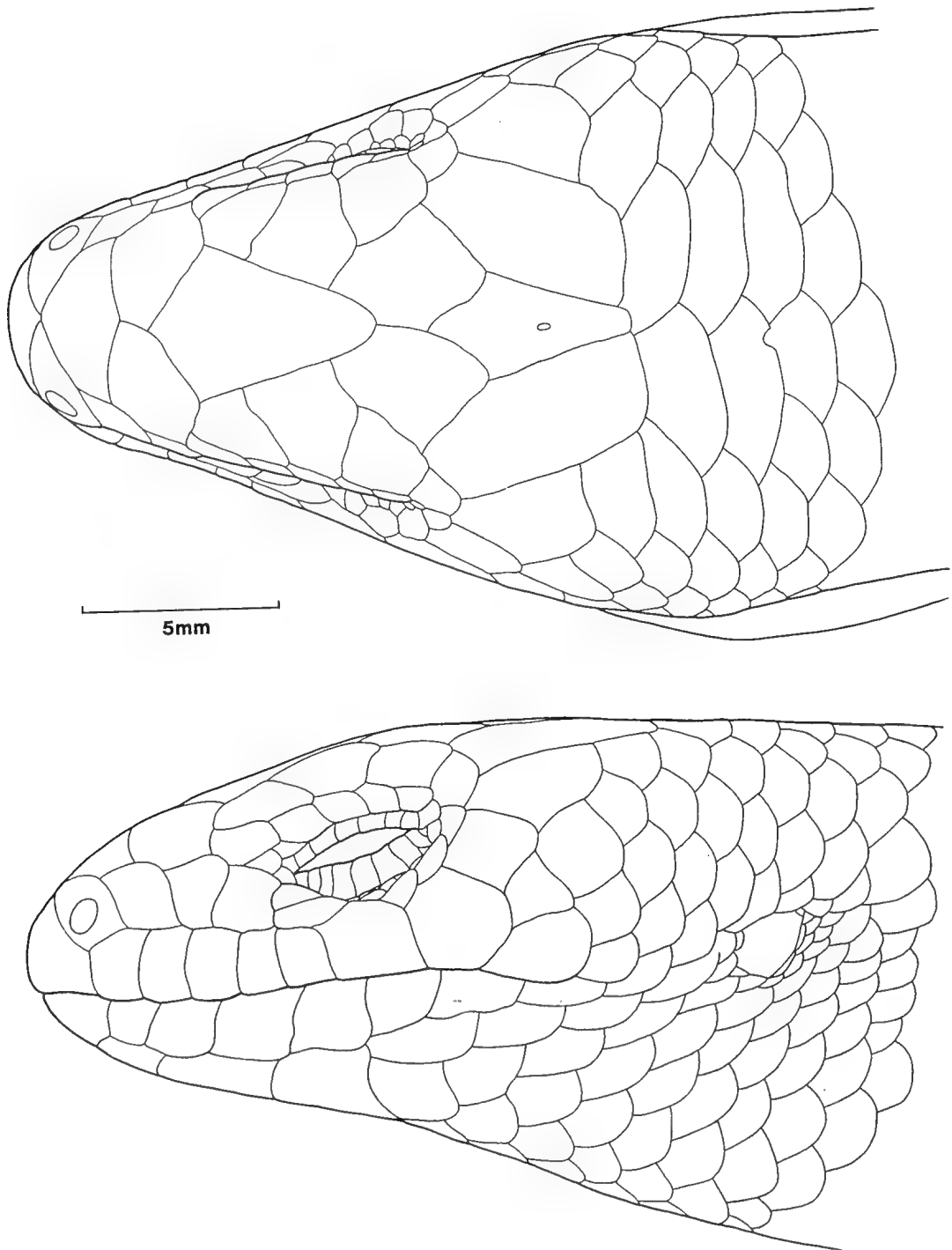


Fig. 14. Dorsal and lateral views of head shields of holotype of *Cyclodomorphus michaeli*.

Mature males with turgid testes were collected throughout the year (Fig. 16). However, the largest testes were seen in three males collected in August and early September, while three males collected in October and March had collapsed testes. These data may suggest that mating occurs in late Winter or early Spring, prior to ovulation.

Females (SVL 101–157.5 mm,  $\bar{x}$  = 124.5, sd = 14.51,

$n$  = 16) carried from 4–16 ( $\bar{x}$  = 8.3, sd = 3.32,  $n$  = 16) enlarged yolking ovarian follicles or oviducal yolks or embryos. There was a significant positive correlation between litter size and maternal SVL (litter =  $0.153\text{SVL} - 10.801$ ;  $r = 0.6693^{**}$ ). Timms (1977) reports a litter of 13 born on 24 and 26 January ( $n$  = 11, 2 respectively) to a female (SVL 158 mm) from Cooranbong, NSW, collected on the former date. Relative litter mass

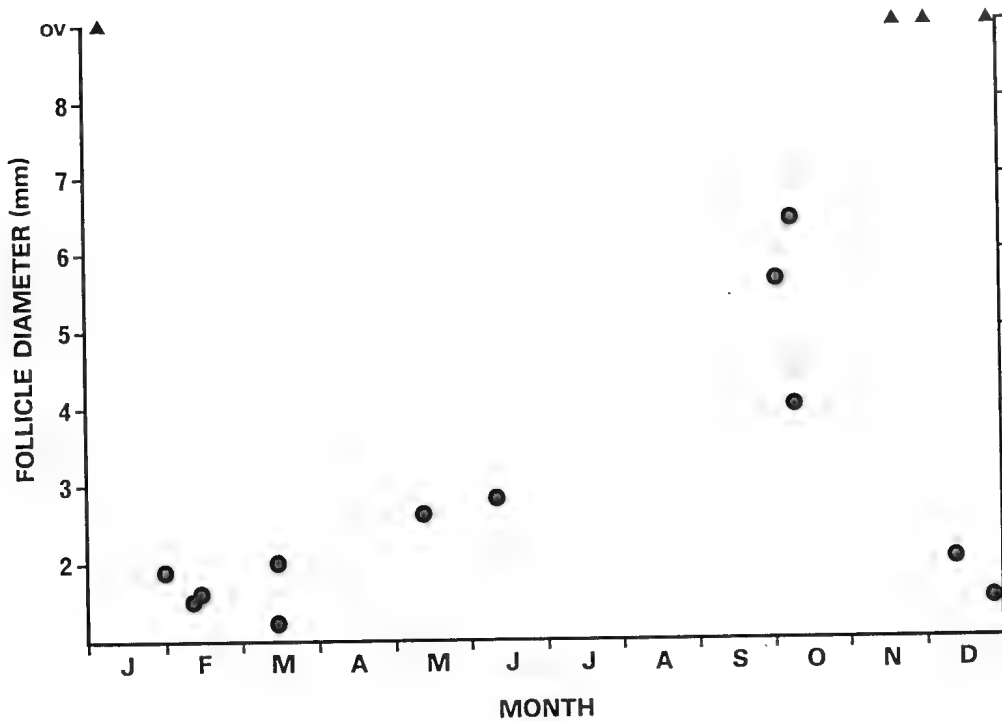


Fig. 15. Seasonal variation in size of largest ovarian follicle, and occurrence of oviducal embryos (ov) in *C. michaeli*.

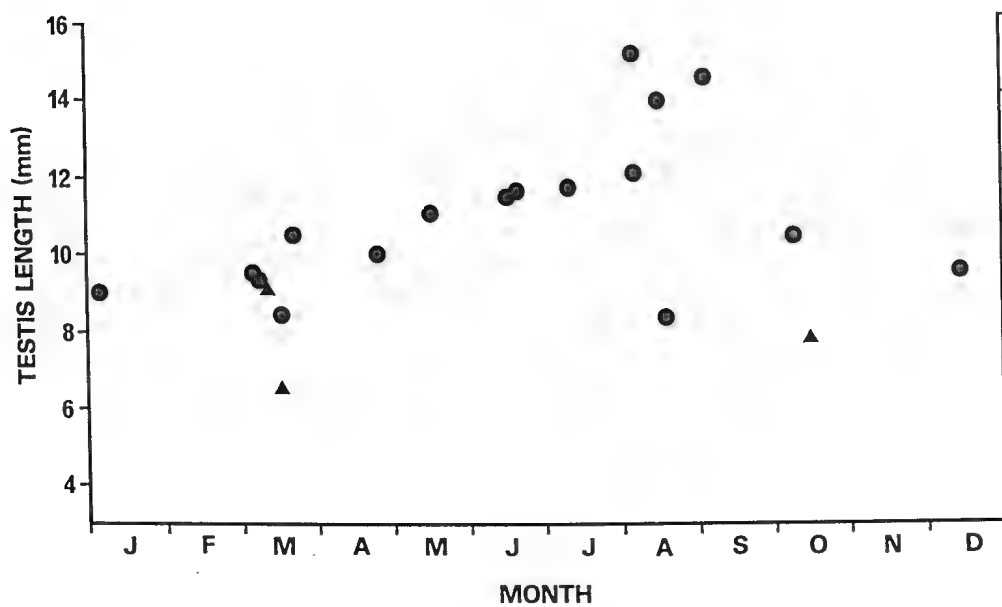


Fig. 16. Seasonal variation in testis length in *C. michaeli*. Dots are turgid rounded testes, triangles are flaccid or flattened testes.



(progeny mass/post-parturient female mass) was 0.302, with individual offspring having SVL 41–46 mm ( $\bar{x}$  = 43.7 mm) and mass 0.75–1.44 g ( $\bar{x}$  = 1.10 g). A similarly extended parturition was reported by Palmer (1888) for a female presumably from near Sydney, which gave birth to six young, “three on each of two consecutive days”. Other literature records of litter size for this species are eleven and four (Rankin & Maddocks, in Shea, 1982). Swan (1990) reports litter size for NSW members of the *C. casuarinae* complex as 4–19, born late January to early February, with young about 44 mm SVL.

**Sex ratio.** Overall, the ratio of mature males:females was 32:35, close to 1:1, with animals collected from all months ( $n$  = 1–8). However, females predominated during the period of gestation, while males predominated in other months (Nov–Jan, 2:6; Feb–Oct 19:10), these two ratios being significantly different ( $\chi^2_1$  = 4.05\*)

**Specimens examined.** 1. EDEN REGION, NSW/VIC: AM R57875, Chandlers Creek, 22 miles north Cann River, Vic; R64041, Nadgee Nature Reserve, NSW; MV D33721–23, Wroxham, Vic; D39127, D39129, Genoa, Vic; D39146, Gipsy Point, Vic; D39196, Little Ram Head, Vic; D50977, Cape Green, NSW; D51983, 19.6 km north-west Wangan Inlet, Vic; D57447, 10.5 km south-south-west Wangarabell, Vic; D65095, Hard-to-Seek Track, 300 m north-east southern crossing of Hard-to-Seek Creek, Vic; D66126, Stony Creek Track, 1 km east Nash Camp Track, Vic. 2. ILLAWARRA REGION, NSW: AM R1930, R9341–42, Wollongong; R3870, Randwick; R6803, Inglewood, Colo Vale; R7090, Austinmer; R8058, Darlinghurst; R10021, R13412, Centennial Park; R10996, Unanderra; R10998, Rose Bay; R11670, Botany, Mascot; R12314, Coniston via Wollongong; R12771, North Wollongong; R15194, Kangaroo Valley; R18483, Botany; R18766–67, Long Bay; R18770, Malabar; R30277, Wollongong district; R68002, R93762, NTM R0961, SAM R25922, La Perouse; AM R75966, 5 miles east Nerriga; R95721, c. 0.5 km north Macquarie Hill; R102945–46, La Perouse Golf Links; R103160, Mascot; R106832, Mount Cambewarra, near Nowra; R121017, Dapto; R130244, Victoria Street, Gerringong; MV D8572, Sydney; QM J32175, Darkes Forest. 3. BLUE MOUNTAINS, NSW: AM R10139, R11673, R12515, R12561, R12921, R13106, R27381, R65875, Lawson; R12728, R12751, Mount Irvine; R45846, Glenbrook Boys Home, Glenbrook; R45847, Three Sisters, Katoomba; R65870–71, R65876–77, Wentworth Falls; R65873, R67166–68, Katoomba district; R67164, R111948 (type of *C. michaeli*), Mount Victoria; R106362–63, 1.2 km east-south-east Mount Victoria; R106746, 0.5 km south Mount Victoria; R120855, Woodford; NTM R4829, Wentworth Falls township; R4830–32, Wentworth Falls Lake; SAM R8787–89, mountains behind Sydney. 4. CENTRAL COAST, NSW: AM R7099, Wyong; R8290–91, R8702, Somersby; R12251, Dora Creek; R16109, Gosford district; R16981, Cooranbong; R21216, Lisarow; R54715, R68348, hill above Boardinghouse Dam, Watagan State Forest, South Cessnock; R54802, 13 km east Raymond Terrace on Williamtown road; R68000, Ourimbah State Forest, north-east Wyong; R68003–04, Heaton Range; R68005, R99461, MV D39131, Gosford; AM R73287, Ourimbah; R75956, Watagan Range; R75967, R92690–91, 7.4 miles south Boardinghouse Dam on Wishing Well Road, Watagan State Forest; R76516, 7.8 km west of main road, on Mount Faulk Road, Watagan State Forest;

R112395, Shortland Swamp; R134999, Narara. 5. BARRINGTON TOPS/NEW ENGLAND, NSW: AM R16085, Barrington Tops; R18961, upper Allyn River; R51692, 6 miles north-north-west Ben Lomond; R139127, Chichester State Forest, east Mount Allyn on Mount Allyn Forest Road (Patterson Forest Road); SAM R8713, Lister Park, c. 30 miles north-east Singleton. UNLOCALISED: AM R14345, Mount Isa; R65872, R65874, Sydney region; MV D57466, no data.

### *Cyclodomorphus praealtus* n.sp.

Figs 17–19

**Type material.** HOLOTYPE: MV D39148, Three Mile Dam, Kiandra, collected by W.A. Rawlinson on 3 November, 1967. PARATYPES: AM R57876, R64896, ANWC R5127–28, MV D8937, D39130, D39132, D39134–37, D39147, D39149–50, D39194–95, D50053, D56467, D56483.

**Diagnosis.** A small *Cyclodomorphus* (maximum SVL 114 mm), differing from all other species in the combination of prefrontals usually contacting, postnarial groove absent, postmental usually contacting two infralabials on each side, subcaudal scales 48–57, midbody scales 24–26, supraciliaries modally five and adult dorsal colour pattern complex, including dark edges to scales and scattered paler scales.

**Description.** Nasals usually in point to broad contact (80.0%,  $n$  = 20), rarely narrowly to moderately separated (20.0%); prefrontals usually in moderate to broad contact (75.0%,  $n$  = 20), less commonly in narrow contact (20.0%), rarely moderately separated (5.0%); transversely enlarged nuchals 2–5 on each side ( $\bar{x}$  = 2.9,  $sd$  = 0.70,  $n$  = 40), usually three (57.5%); loreals usually two bilaterally (90.0%,  $n$  = 20), rarely one unilaterally (10.0%); rarely rostral loreal double unilaterally ( $n$  = 1); supraoculars three bilaterally, rostral two in contact with frontal, second largest; supraciliaries 4–6 ( $\bar{x}$  = 5.3,  $sd$  = 0.53,  $n$  = 40), usually five (62.5%); presuboculars 2–3, usually two (71.8%,  $n$  = 39); postsuboculars 2–4 ( $\bar{x}$  = 3.2,  $sd$  = 0.45,  $n$  = 40), usually three (77.5%); upper palpebrals 6–8 ( $\bar{x}$  = 7.3,  $sd$  = 0.57,  $n$  = 18); lower palpebrals 7–9 ( $\bar{x}$  = 8.1,  $sd$  = 0.70,  $n$  = 17); secondary temporals usually in  $\alpha$ -configuration bilaterally, rarely ( $n$  = 1) in  $\beta$ -configuration unilaterally, or with only a single lower secondary temporal bilaterally ( $n$  = 1); supralabials 6–8 ( $\bar{x}$  = 7.0,  $sd$  = 0.39,  $n$  = 40), usually seven (85.0%), third-last below centre of eye, separating pre- and postsuboculars; infralabials 6–8 ( $\bar{x}$  = 7.2,  $sd$  = 0.68,  $n$  = 38), usually seven (50.0%) or eight (34.2%); usually first two infralabials contacting postmental, rarely first only unilaterally ( $n$  = 1); ear very small, usually with a single small lobule along rostral margin (76.3%,  $n$  = 38), rarely two (10.5%) or three (2.6%) or lobules absent (10.5%).

Body scales in 24–26 ( $\bar{x}$  = 25.0,  $sd$  = 0.97,  $n$  = 20) longitudinal rows at midbody; scales in paravertebral rows not or only slightly broader than adjacent scales,





Fig. 17. A live individual of *Cyclodomorphus praealtus* from Smiggin Holes (photograph by W. Osborne).

62–75 ( $\bar{x}$  = 68.9,  $sd$  = 3.58,  $n$  = 20); subcaudal scales 48–57 ( $\bar{x}$  = 53.1,  $sd$  = 2.34,  $n$  = 11); lamellae below fourth toe 8–12 ( $\bar{x}$  = 10.1,  $sd$  = 0.92,  $n$  = 40).

SVL 44–119 mm ( $n$  = 20); AGL/SVL 59.1–68.5% ( $\bar{x}$  = 64.1%,  $n$  = 20); TL/SVL 47.7–77.6% ( $\bar{x}$  = 67.3%,  $n$  = 11); FLL/SVL 12.3–16.7% ( $\bar{x}$  = 13.8%,  $n$  = 20); HLL/SVL 15.5–22.7% ( $\bar{x}$  = 18.5%,  $n$  = 20); FLL/HLL 69.8–81.3% ( $\bar{x}$  = 74.7%,  $n$  = 20); HL/SVL 14.3–20.5% ( $\bar{x}$  = 15.6%,  $n$  = 20); HW/HL 64.0–74.0% ( $\bar{x}$  = 68.2%,  $n$  = 19); HD/HL 50.9–61.2% ( $\bar{x}$  = 55.4%,  $n$  = 19).

**Coloration (in preservative).** Dorsal ground color yellow-brown to dull olive-green or grey. On body and tail, centres of individual scales a little darker, often with very fine mid-brown streaks, lateral parts of scales paler, sometimes cream; extreme lateral margins of most dorsal body and basal tail scales with dark brown to black edges, producing a series of weak, irregularly defined, often broken, narrow dark longitudinal stripes, extending onto base of tail, often continued by pale stripes distally as dark margins are reduced and disappear. On body, some transverse rows of scales (generally alternate) may be paler.

Head dorsum immaculate or (more commonly) with black flecks and spots along shield margins, tending to coalesce into dark margins to some shields.

Laterally, body and tail with dorsal ground color, gradually replaced ventrally by paler ventral ground colour. Many scales in alternate transverse scale rows largely black, especially centrally and apically, these dark macules often with cream edges laterally or basally, producing a series of roughly parallel, irregular, narrow dark bars, separated by one to three rows of unspotted scales.

Face with dorsal ground color, individual shields margined by black spots and flecks, especially around eye and adjacent supralabial shields.

Venter blue-grey to yellow, immaculate or with varying density and contrast of dark margins and central dark flecks to scales, leading to an often irregular pattern of narrow dark stripes or variegations on at least body, less commonly on throat and tail.

Limbs yellow-brown to green-grey above, grey-blue to yellow below, with fine dark streaks and spots. Soles yellow-brown, sometimes with slightly darker calli on granules and lamellae.

Juvenile coloration similar to adults, but with more prominent and contrasting dark and light markings on head, especially on face and sides of neck.

**Coloration (in life)** (Fig. 17). I have not examined any live individuals of this taxon. However, AM R57876 was reported to have had “much bright red,



Fig. 18. Holotype of *Cyclodomorphus praealtus* n.sp. (MV D39148).

practically vermillion" ventrally (S.J. Copland field notes, on file in AM), a coloration not now present in this specimen. Colour transparencies of live individuals taken by W. Osborne show orange-red irides, and a dorsal and lateral ground colour suffused with red, particularly on a subadult.

**Allometry** (Table 7). With respect to SVL, AGL and TL show positive allometry, while FLL, HLL and HL show negative allometry. Neither HW and HD (with respect to HL) nor FLL (with respect to HLL) show significant departures from isometry.

**Sexual dimorphism.** Sample sizes for males are too small to adequately test for sexual dimorphism. In most cases, the magnitude and direction of difference between the mean values for males and females is similar to that seen in *C. casuarinae* and *C. michaeli*.

**Distribution.** Australian Alps, above 1500 m, from Kiandra in the north to Mount Hotham in the south (Fig. 1). In addition to the localities cited below, there are several literature records of *C. casuarinae* from the Australian Alps that are probably based on this species: Daner's Gap (Loveridge, 1934; see also Copland, 1947); Mount Buffalo National Park (Jenkins & Bartell, 1980) and Mount Higginbotham (Norris *et*

*al.*, 1983). P. Harlow (pers. comm.) observed an individual of this species at 200 m east of Valentine Hut, on the banks of Valentine Creek at 1680 m in February 1990. This locality is about 10 km north of Guthega Power Station, NSW. W. Osborne (pers. comm.) has recorded the species from Smiggin Holes, Daner's Gap, Mount Blue Cow (36°23'S 148°23'E, 1550 m), Mount Guthrie (36°25'S 148°20'E, 1800 m) and Etheridge Range (36°27'S 148°16'E, 2020 m).

**Details of holotype.** The holotype (Figs 18, 19) is a gravid female with the following combination of character states: nasals in broad contact; prefrontals in moderate contact; presuboculars two; postsuboculars three; supraciliaries five; supralabials seven; infralabials seven; rostral ear lobules one; nuchals three; upper palpebrals 7/8; lower palpebrals 9/8; midbody scales 24; paravertebral scales 73; subcaudal scales 52; subdigital lamellae ten; SVL 93 mm; AGL 61 mm; TL 57 mm; FLL 11.5 mm; HLL 16 mm; HL 14.2 mm; HW 9.2 mm; HD 7.7 mm. There are 2L/3R oviducal egg masses.

**Etymology.** The specific epithet is from the Latin *praealtus*, very high, and alludes to the high altitudes inhabited by this species.

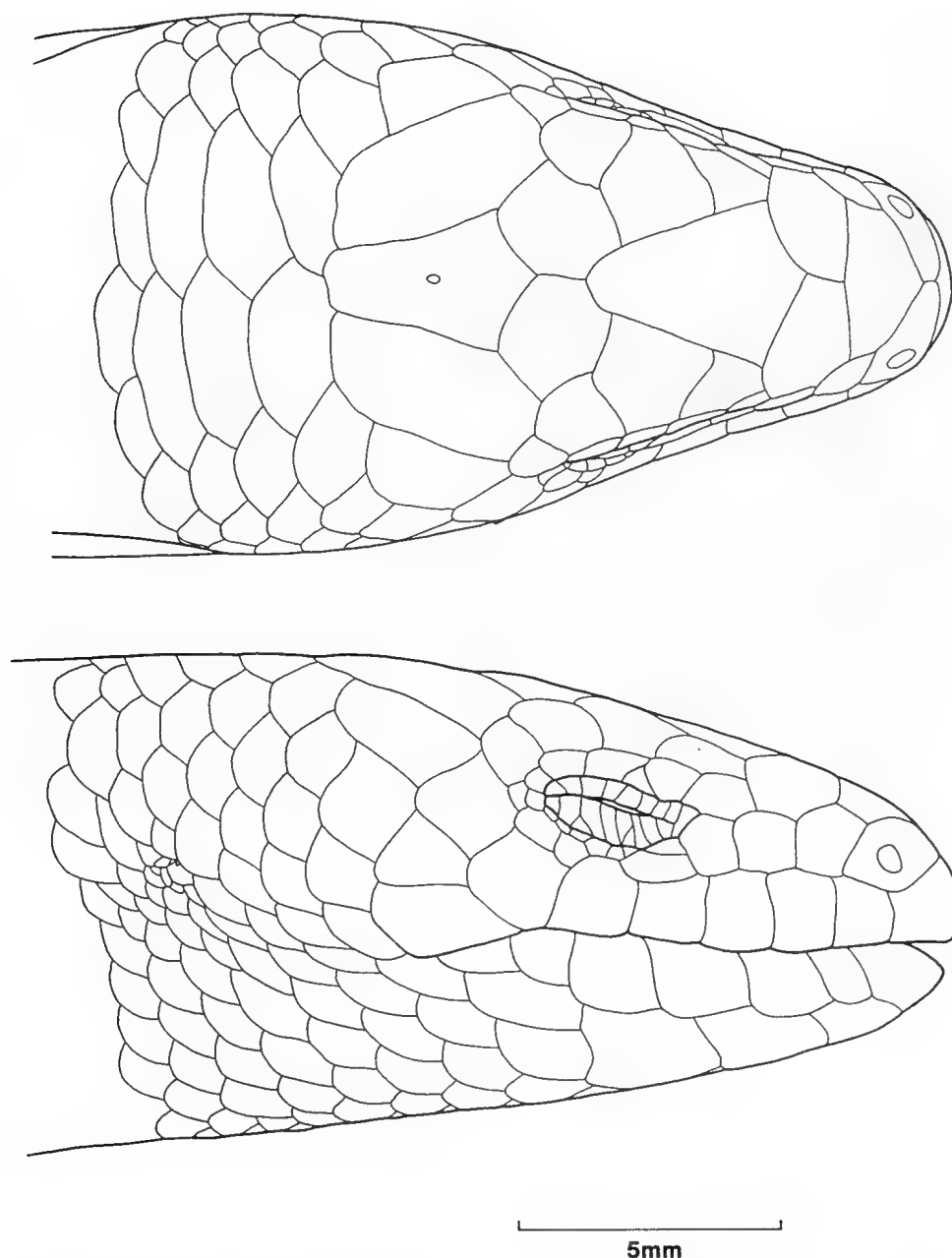


Fig. 19. Dorsal and lateral views of head shields of holotype of *Cyclodomorphus praealtus*.

**Habitat and habits.** Little is known of the habitat preferences and habits of this species. The specimen from Daner's Gap reported by Loveridge (1934) was taken from a *Myrmecia* nest, the Mount Higginbotham record was found amongst ground litter in subalpine woodland (Norris *et al.*, 1983), the Lankey Plain specimen (MV D50053) was found frozen in snow (Cherry *et al.*, 1987; note, however, that the specimen is a neonate, not an adult as reported by Cherry *et al.*) in an alpine herbfield (Norris *et al.*, 1983) and AM R57876 was found under stones in grass (S.J. Copland

field notes), while the individual observed by Harlow was basking in a grass tussock by day.

W. Osborne (pers. comm.) has field data on six individuals: one from Mount Blue Cow disturbed from grass cover in open shrubland of *Grevillea australis*, *Prostanthera cuneata* and *Orites lancifolia* over *Poa*; one from Mount Guthrie captured in a small mammal trap in open shrubland with grassy ground cover; a subadult from Etheridge Range collected in a tall alpine herbfield dominated by *Poa*; a subadult from Daner's Gap was found active, moving over sod tussock grass-

land with scattered emergent shrubs; a gravid female from Smiggin Holes basking on grass surface in *Poa* grassland clearing in *Bossiae foliosa* open shrubland, and a second animal from the same locality disturbed from within a grass tussock in *Poa* tussock grassland in an area disturbed by clearing of trees and taller shrubs at the edge of a ski run. On the basis of his experience, Osborne considers the preferred habitat to be open shrubland with a thick ground cover of snow grasses (*Poa* spp.). The species appears to be absent from many alpine habitats, including snow gum forest, wet heath, bog, rock outcrops or wet grassland (W. Osborne, pers. comm.).

Preferred body temperatures of 27.8–33.0°C ( $\bar{x}$  = 31.2°C) have been reported for a single animal from Kosciusko National Park (Bennett & John-Alder, 1986).

**Reproduction.** Of the 20 specimens examined, one was a neonate, three (SVL 89–97.5 mm) were mature males, and the remainder (81–119 mm;  $\bar{x}$  = 102.9 mm,  $sd$  = 9.51,  $n$  = 16) were mature females. The two males for which dates of collection were known were collected 9–28 March, and had grossly enlarged, turgid testes 14 mm long. Of the females, 13 (SVL 81–119,  $\bar{x}$  = 101.9 mm,  $sd$  = 10.32), collected 3 November ( $n$  = 4), 2–4 January ( $n$  = 5), 3 February ( $n$  = 2) and 2 March

( $n$  = 2) were gravid, with 2–9 ( $\bar{x}$  = 4.9,  $sd$  = 1.97) oviducal embryos, those collected in March being fully scaled and pigmented. All of the three non-gravid mature females (SVL 105–108 mm) were collected in January, although two were held in captivity for varying periods before death. Two gravid females collected by W. Osborne gave birth to litters of two and five young at the end of February.

There is a positive correlation between litter size and maternal SVL (litter =  $0.126SVL - 7.96$ ;  $r = 0.6595^*$ ).

**Sex ratio.** The adult sex ratio is heavily skewed towards females (3:16;  $\chi^2_1 = 7.58^*$ ). A similar seasonal pattern to that seen in other species was apparent, with only females found between November and 2 March, during the gestation period, and two males collected on 9 and 28 March.

**Specimens examined.** AM R57876, MV D8937, Mount Hotham; AM R64896, ANWC R5127–28, MV D39130, D39132, D39134–37, Smiggin Holes; MV D39147–50, Three Mile Dam, Kiandra; D39194, Mount Hotham Hotel (top); D39195, Mount Hotham Ski Lodges (top); D50053, Lankey Plain; D56467, 0.7 km south-west Mount Loch; D56483, 0.3 km north Loch car park, Mount Hotham.

#### A key to the species of the *Cyclodomorphus casuarinae* complex

1. Tail short, subcaudals on original tails 57 or fewer; midbody scales 24 or more; Australian Alps ..... *C. praealtus*
- Tail moderate to long, subcaudals on original tails 68 or more; midbody scales usually 24 or fewer ..... 2
2. Subcaudals on original tails 84 or fewer; dorsal colour pattern often complex; Tasmania ..... *C. casuarinae*
- Subcaudals on original tails usually 91 or more; dorsal colour pattern usually simple, either immaculate or with dark margins to scales; Victoria or New South Wales ..... *C. michaeli*

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Table 1. Proportions of correct identification of specimens to populations and population groups by canonical variates analysis.

Population	n	correct popn	non-alpine mainland	alpine	Tasmanian
Barrington	3	100.0%	100.0%	—	—
Central Coast	22	63.6%	95.5%	—	4.5%
Blue Mountains	30	56.7%	93.3%	—	6.7%
Wollongong	30	56.7%	80.0%	3.3%	16.7%
Eden	11	100.0%	100.0%	—	—
Total	96	64.6%	90.6%	1.0%	8.3%
Alps	19	84.2%	5.3%	84.2%	10.5%
north-east Tas.	22	59.1%	13.6%	4.5%	81.8%
north-west Tas.	16	75.0%	—	—	100.0%
central Tas.	20	55.0%	15.0%	—	85.0%
south-east Tas.	30	76.7%	—	—	100.0%
unlocalised Tas.	9	—	11.1%	—	88.9%
Total	97	67.0%	7.2%	1.0%	91.8%
Grand total	203	67.5%			

Table 2. Standardised canonical coefficients (and correlations with canonical functions) for 16 characters from all ten populations of the *C. casuarinae* complex. Canonical coefficients standardised by within-groups standard deviations.

Function	I	II	III	IV	V	VI
SVL	0.330 (0.073)	-0.026 (0.046)	0.274 (0.194)	0.136 (0.072)	-0.162 (-0.111)	0.259 (0.528)
AGL	-0.205 (-0.558)	0.174 (0.024)	0.035 (0.103)	0.079 (0.264)	0.110 (-0.102)	0.384 (0.056)
FLL	0.220 (0.685)	0.435 (0.203)	0.852 (0.182)	-0.484 (-0.276)	0.475 (0.290)	-0.556 (-0.243)
HLL	0.302 (0.620)	-0.090 (0.213)	-0.303 (0.049)	0.422 (-0.048)	-0.142 (0.235)	-0.087 (0.009)
HL	-0.209 (0.634)	0.239 (0.014)	-0.288 (-0.034)	-0.762 (-0.411)	-0.107 (0.036)	0.829 (0.309)
HW	0.359 (0.522)	-0.107 (-0.021)	0.126 (0.038)	0.446 (-0.166)	0.083 (0.019)	-0.121 (0.058)
NAS	-0.096 (-0.042)	-0.053 (-0.116)	0.419 (0.422)	0.417 (0.447)	0.303 (0.228)	0.081 (0.141)
PFR	-0.429 (-0.323)	0.069 (0.048)	0.010 (0.136)	-0.252 (-0.247)	0.043 (0.019)	0.253 (0.274)
POS	0.030 (0.123)	0.189 (0.129)	-0.223 (-0.196)	0.176 (0.060)	0.466 (0.400)	0.156 (0.248)
PRS	-0.130 (-0.070)	-0.056 (-0.058)	0.146 (0.004)	-0.005 (0.033)	0.633 (0.543)	0.103 (0.115)
SCIL	0.146 (0.185)	0.388 (0.312)	-0.236 (-0.107)	0.095 (-0.069)	-0.072 (-0.017)	-0.191 (-0.256)
ILAB	0.013 (0.139)	-0.162 (-0.013)	0.061 (0.169)	-0.037 (-0.070)	0.390 (0.395)	0.236 (0.259)
NUCH	-0.074 (-0.268)	0.117 (0.099)	0.298 (0.267)	0.388 (0.345)	-0.106 (-0.203)	-0.230 (-0.240)
MB	0.284 (0.271)	-0.807 (-0.574)	0.331 (0.386)	0.005 (-0.277)	-0.224 (-0.168)	-0.051 (0.059)
PV	-0.324 (-0.458)	0.333 (0.201)	0.534 (0.464)	-0.650 (-0.289)	0.121 (-0.141)	-0.234 (0.012)
SUBLAM	0.178 (0.218)	0.493 (0.446)	0.220 (0.343)	0.276 (0.147)	-0.367 (-0.255)	0.408 (0.413)
Canonical Correlations	0.810	0.791	0.581	0.569	0.503	0.368



Table 3. Allometric equations and calculated values for cranial and somatic proportions in *C. casuarinae*. Values *a* and *b* solve the equation  $y = bx^a$ , *r* = correlation coefficient, s.e. = standard error of *a*, *C*<sub>42</sub>, *C*<sub>103</sub> and *C*<sub>174</sub> are calculated percentage proportions (*y*/*x*) at SVL = 42, 103 and 174 mm (minimum, minimum mature female and maximum size). Sample sizes are as for ratios.

<i>y</i>	<i>x</i>	<i>a</i>	<i>b</i>	<i>r</i>	s.e.	<i>C</i> <sub>42</sub>	<i>C</i> <sub>103</sub>	<i>C</i> <sub>174</sub>
AGL	SVL	1.150	0.313	0.998	0.007	54.8	62.7	67.9
TL	SVL	1.431	0.149	0.990	0.025	74.6	109.8	137.7
FLL	SVL	0.755	0.479	0.984	0.013	19.2	15.4	13.5
HLL	SVL	0.866	0.392	0.986	0.014	23.8	21.1	19.6
FLL	HLL	0.865	1.101	0.992	0.011	80.7	72.7	68.4
HL	SVL	0.653	0.818	0.982	0.012	22.4	16.4	13.7
HW	HL	0.976	0.723	0.980	0.019	68.5	67.6	67.0
HD	HL	0.931	0.613	0.972	0.022	52.5	50.4	49.3

Table 4. Sexual dimorphism in cranial and somatic proportions in *C. casuarinae*. Tests of significance (i) and allometric and calculated values for males (ii) and females (iii) in sexually dimorphic characters. Conventions for (ii) and (iii) as for Table 1. *C*<sub>85</sub> and *C*<sub>126</sub> are calculated proportions at SVL = 85, 126 mm (minimum mature and maximum SVL for males, the smaller sex).

(i)

<i>y</i>	<i>x</i>	slopes			intercepts		
		<i>F</i>	d.f.	<i>P</i>	<i>F</i>	d.f.	<i>P</i>
AGL	SVL	0.361	1,88	n.s.	13.646	1,89	***
TL	SVL	26.441	1,52	***	—	—	—
FLL	SVL	0.153	1,88	n.s.	12.797	1,89	***
HLL	SVL	6.552	1,88	*	—	—	—
HL	SVL	10.750	1,88	***	—	—	—
HW	HL	6.047	1,88	*	—	—	—
HD	HL	1.994	1,87	n.s.	0.871	1,88	n.s.
FLL	HLL	9.710	1,89	**	—	—	—

(ii)

<i>y</i>	<i>x</i>	<i>a</i>	<i>b</i>	<i>r</i>	s.e.	<i>n</i>	<i>C</i> <sub>85</sub>	<i>C</i> <sub>126</sub>
AGL	SVL	1.139	0.324	0.997	0.015	35	60.1	63.5
TL	SVL	1.531	0.102	0.996	0.031	24	107.9	133.0
FLL	SVL	0.771	0.457	0.984	0.025	35	16.5	15.1
HLL	SVL	0.949	0.283	0.993	0.020	35	22.6	22.1
HL	SVL	0.661	0.801	0.986	0.020	35	17.8	15.5
HW	HL	0.874	0.946	0.976	0.034	35	67.2	65.0
FLL	HLL	0.812	1.271	0.992	0.018	35	72.9	68.0

(iii)

<i>y</i>	<i>x</i>	<i>a</i>	<i>b</i>	<i>r</i>	s.e.	<i>n</i>	<i>C</i> <sub>85</sub>	<i>C</i> <sub>126</sub>
AGL	SVL	1.125	0.355	0.994	0.017	57	61.9	65.0
TL	SVL	1.167	0.514	0.957	0.065	32	107.9	115.3
FLL	SVL	0.786	0.405	0.958	0.032	57	15.7	14.4
HLL	SVL	0.853	0.409	0.964	0.032	57	21.3	20.1
HL	SVL	0.779	0.444	0.962	0.030	57	16.6	15.2
HW	HL	1.006	0.668	0.957	0.041	57	67.9	68.0
FLL	HLL	0.909	0.960	0.979	0.025	58	73.8	71.5

Table 5. Allometric equations and calculated values for cranial and somatic proportions in *C. michaeli*. Values a and b solve the equation  $y = bx^a$ , r = correlation coefficient, s.e. = standard error of a,  $C_{40}$ ,  $C_{101}$  and  $C_{174}$  are calculated percentage proportions (y/x) at SVL = 40, 101 and 174 mm (minimum, minimum mature female and maximum size). Sample sizes are as for ratios.

y	x	a	b	r	s.e	$C_{40}$	$C_{101}$	$C_{174}$
AGL	SVL	1.159	0.313	0.998	0.007	56.3	65.2	71.1
TL	SVL	1.335	0.285	0.984	0.034	98.1	133.7	160.5
FLL	SVL	0.705	0.537	0.953	0.022	18.1	13.8	11.7
HLL	SVL	0.838	0.400	0.960	0.023	22.0	18.9	17.3
FLL	HLL	0.835	1.183	0.985	0.014	82.6	72.7	67.4
HL	SVL	0.611	0.914	0.970	0.015	21.8	15.2	12.3
HW	HL	0.923	0.818	0.970	0.023	69.2	66.3	64.6
HD	HL	0.959	0.600	0.958	0.028	54.9	53.6	52.9

Table 6. Sexual dimorphism in cranial and somatic proportions in *C. michaeli*. Tests of significance (i) and allometric and calculated values for males (ii) and females (iii) in sexually dimorphic characters. Conventions for (ii) and (iii) as for Table 1.  $C_{74}$  and  $C_{128}$  are calculated proportions at SVL = 74, 128 mm (minimum mature and maximum SVL for males, the smaller sex).

(i)

y	x	slopes			intercepts		
		F	d.f.	P	F	d.f.	P
AGL	SVL	0.016	1,98	n.s.	35.933	1,99	***
TL	SVL	14.406	1,47	***	—	—	—
FLL	SVL	7.136	1,98	**	—	—	—
HLL	SVL	8.815	1,98	**	—	—	—
HL	SVL	2.234	1,98	n.s.	44.584	1,99	***
HW	HL	0.173	1,91	n.s.	0.075	1,92	n.s.
HD	HL	1.696	1,97	n.s.	0.816	1,98	n.s.
FLL	HLL	0.282	1,99	n.s.	2.925	1,100	n.s.

	y	x	a	b	r	s.e.	n	$C_{74}$	$C_{128}$
(ii)	AGL	SVL	1.131	0.351	0.998	0.011	52	61.7	66.3
	TL	SVL	1.485	0.152	0.986	0.047	31	122.6	159.9
	FLL	SVL	0.814	0.341	0.966	0.031	52	15.3	13.8
	HLL	SVL	0.962	0.240	0.978	0.029	52	20.4	20.0
	HL	SVL	0.682	0.681	0.972	0.023	52	17.3	14.6
(iii)	AGL	SVL	1.133	0.358	0.998	0.010	50	63.5	68.3
	TL	SVL	1.254	0.394	0.992	0.037	20	117.6	135.1
	FLL	SVL	0.694	0.546	0.951	0.033	50	14.6	12.4
	HLL	SVL	0.834	0.386	0.967	0.032	50	18.9	17.3
	HL	SVL	0.639	0.777	0.983	0.017	50	16.4	13.5

Table 7. Allometric equations and calculated values for cranial and somatic proportions in *C. praealtus*. Values a and b solve the equation  $y = bx^a$ , r = correlation coefficient, s.e. = standard error of a,  $C_{44}$ ,  $C_{81}$  and  $C_{119}$  are calculated percentage proportions (y/x) at SVL = 44, 81 and 119 mm (minimum, minimum mature female and maximum size). Sample sizes are as for ratios.

y	x	a	b	r	s.e.	$C_{44}$	$C_{81}$	$C_{119}$
AGL	SVL	1.113	0.382	0.992	0.033	58.6	62.8	65.6
TL	SVL	1.416	0.102	0.983	0.088	49.2	63.5	74.5
FLL	SVL	0.800	0.344	0.911	0.085	16.1	14.3	13.2
HLL	SVL	0.735	0.620	0.900	0.084	22.7	19.3	17.5
FLL	HLL	1.050	0.647	0.977	0.054	72.6	74.2	75.3
HL	SVL	0.646	0.783	0.947	0.052	20.5	16.5	14.4
HW	HL	1.069	0.565	0.963	0.073	65.8	67.6	68.7
HD	HL	0.980	0.584	0.951	0.077	55.9	55.4	55.2



## Notes on Australian Zodariidae (Araneae), I. New Taxa and Key to the Genera

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**ABSTRACT.** A key to the genera of Australian Zodariidae is provided. Four new genera are described. The first, *Australutica* n.gen., belongs in the subfamily Lachesaninae and is represented by the four new species: *A. moreton* (type species, ♂), *A. xystarches* (♀), *A. manifesta* (♂) and *A. quaerens* (♂). The three other new genera belong in the Zodariinae, they are *Australorena* n.gen. with *A. scenica* (Koch) (type species), *Chilumena* n.gen. with *C. reprobans* n.sp. (♂, type species) and *C. baehrorum* n.sp. (♀), and *Zillimata* n.gen. with *Z. scintillans* (Pickard-Cambridge) (type species). Two species, *Habronestes calamitosus* n.sp. (♂, ♀) and *Asceua expugnatrix* n.sp. (♂, ♀), are described in existing genera.

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The Australian Zodariidae is a speciose group. Before Jocqué's generic revision of the Zodariidae in 1991 (Jocqué, 1991) only c. 35 species had been described, but now it would seem that the family is probably as rich as it is in Africa, where almost 200 species are known and many more await description. The remarkable situation whereby almost all the Australian species were united in one genus arose when Pickard-Cambridge (1869: 52) "recognized at once" Walckenaer's genus *Storena*. However, *Storena* was very poorly described and not recognisable with certainty as no types had been designated. Koch (1872) tried to rearrange the situation by recombining all the known Australian species, except the type species *Storena cyanea* Walckenaer, in *Habronestes* Koch. This proved unworkable and complicated the situation even further. Later authors (Bradley, 1878; Dunn, 1951; Hickman, 1944; Rainbow, 1916, 1920; Simon, 1908; Strand, 1913; Thorell, 1881),

continued to describe new species in *Storena*. Finally several new genera had to be created (Jocqué, 1991) in order to accommodate this wide variety of taxa. This was done in a revision of the zodariid genera together with a new delimitation of its subfamilies. In a recent paper (Jocqué, 1992) the division between the Zodariinae and the Storeninae had to be abandoned for reasons already suggested by the cladistic analysis in the generic revision.

In the interim the genus *Storena* has been revised (Jocqué & Baehr, 1992) and now contains 32 species. During that study it appeared that a number of species, new as well as previously described, could not be accommodated in the genera described to date.

The first part of this paper on Australian Zodariidae clears the situation by creating a generic framework in which the majority of the Australian species of Zodariidae will fit. A key to the Australian genera of Zodariidae

is also provided. (In an earlier key to genera [Jocqué 1991: 30] a missprint can be corrected by inverting the sentences in couplet 43, so that "chilum clearly defined and double" keys to 44.)

Near the end of these studies it has become clear that even more genera will be needed to accommodate the entire Australian zodariid fauna. Unfortunately this is beyond the scope of the present study, nevertheless, the majority of Australian zodariid species can now be classified.

### Methods

The format is similar to that used by Jocqué & Baehr (1992). All measurements are in millimetres. Drawings of palps always show the right one.

**Abbreviations.** ALE—anterolateral eyes; AME—anteromedial eyes; AS—anterior spinnerets; AW—anterior width; d—dorsal or diameter (see below); *dw*—distal whorl; *disp*—dispersed, not in obvious rows; F—femur; L—length; MOQ—median ocular quadrangle; Mt—

metatarsus; PLE—posterolateral eyes; PME—posteromedial eyes; *pl*—prolateral; P—patella; PW—posterior width; *rl*—retrolateral; t—tarsus; T—tibia; Tot—total; v—ventral; *w*—whorls (meaning a number of spines which stay in a whorl on a particular segment of the leg, though not always exactly on the section. It is often difficult to tell whether these spines are dorsal, ventral or lateral); \*—spines in a row; \*\*—spines in two rows.

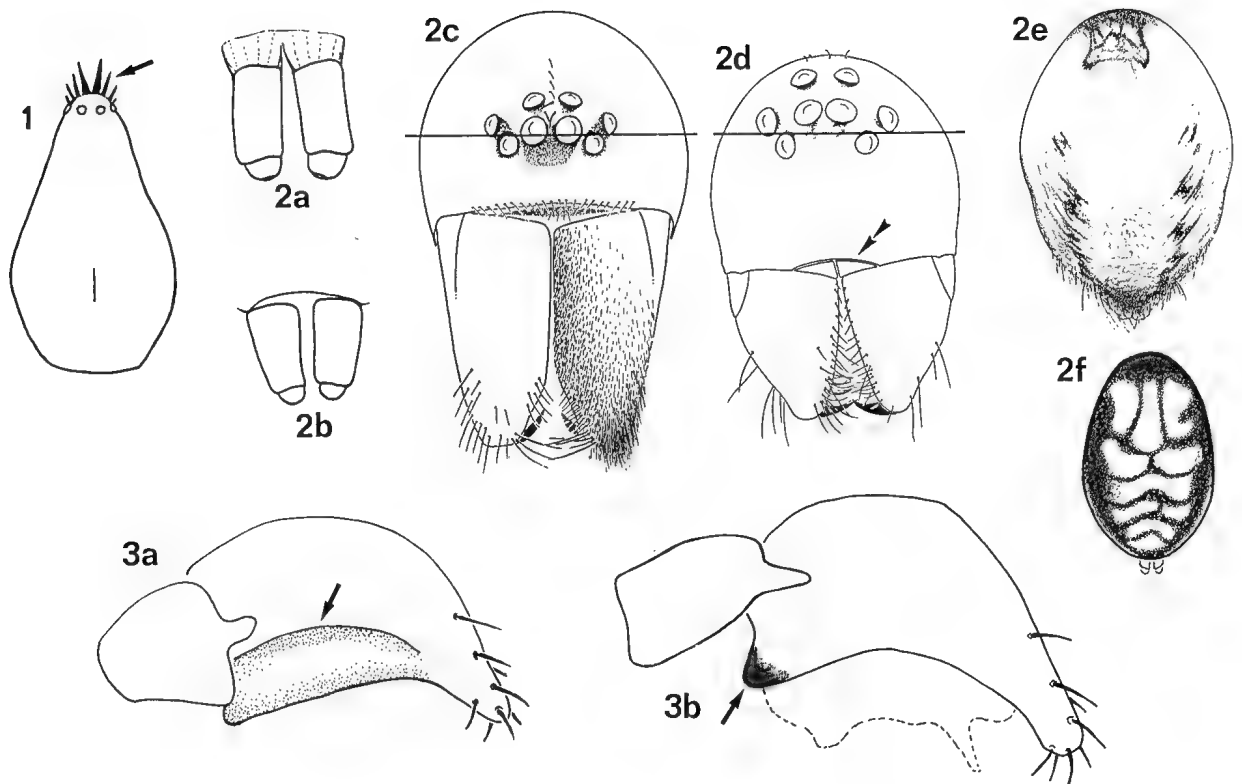
Abbreviations in connection with eye measurement and position: a, b, c and d—diameter, in millimetres, of AME, ALE, PME and PLE respectively; e—AME-AME; f—AME-ALE; g—PME-PME; h—PME-PLE.

Museums and institutions: CAS—California Academy of Sciences (W. Pulawski & D. Ubick); KBIN—Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussels (L. Baert); QM—Queensland Museum, Brisbane (R. Raven); SAMA—South Australian Museum, Adelaide (D. Hirst); UMO—University Museum, Hope Entomology Collections (J. Lansbury); WAM—Western Australian Museum, Perth (M. Harvey); ZSM—Zoologische Sammlung des Bayerischen Staates, Munich (M. Baehr).

### Key to the Australian Genera of Zodariidae \*

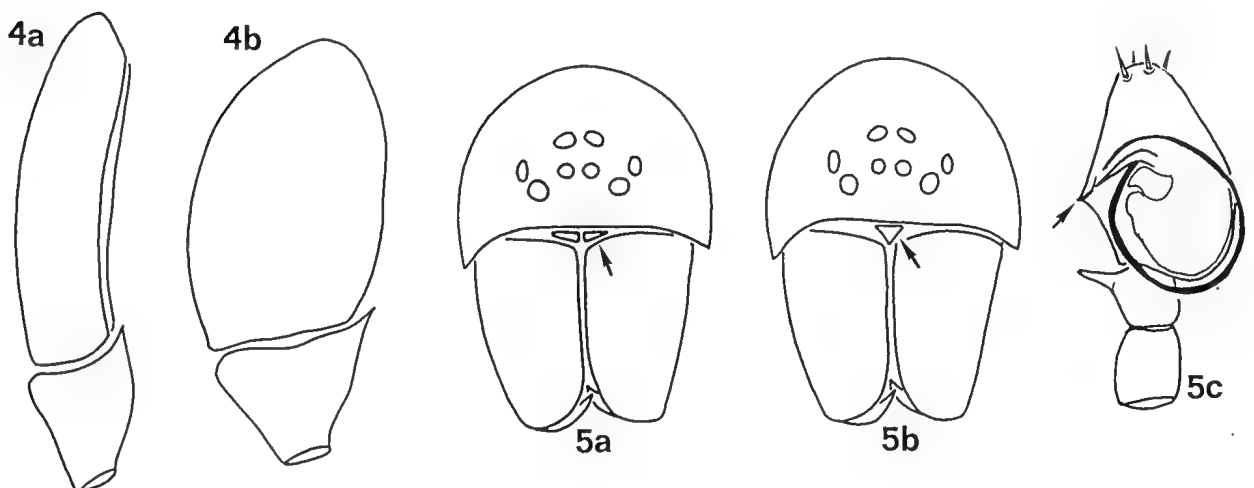
1. Carapace with a transverse row of spines in ocular area (Fig. 1) ..... CYRIOCTEINAE *Cyrioctea*
- Carapace without a row of spines in ocular area ..... 2
2. Anterior spinnerets cylindric and retractile (Fig. 2a); anterior row of eyes not strongly procurved, so that line linking upper margin of ALE runs through AME (Fig. 2c); abdominal pattern if present consisting of poorly delimited dark patches on pale background (Fig. 2e) ..... LACHESANINAE *Australutica*
- Anterior spinnerets conical and only partly retractile (Fig. 2b) anterior row of eyes strongly procurved, so that line linking upper margin of ALE does not run through AME (Fig. 2d) or if it does then dorsal abdominal pattern consisting of well delimited pale spots on dark background (Fig. 2f) ..... ZODARIINAE 3
3. Cymbium of male palp with lateral fold (Fig. 3a), sometimes with pointed "exit"; fold may be restricted to basal half of cymbium ..... 4
- Cymbium of male palp with lateral flange (Fig. 3b) or thickened lateral margin ..... 7
4. Small spiders (<4.5 mm) with male palpal cymbium strip-like as seen from above (Fig. 4a), due to the enormous lateral fold; epigynum with superficial, wound ducts; spines reduced to a few on femora; no spines behind the tracheal opening ..... *Asceua*
- Larger spiders, with normal oval cymbium (Fig. 4b); ducts usually not visible in uncleared epigyne; legs with numerous spines; sometimes with spines behind tracheal opening ..... 5

\* *Hetaerica* not included, known only from juvenile.

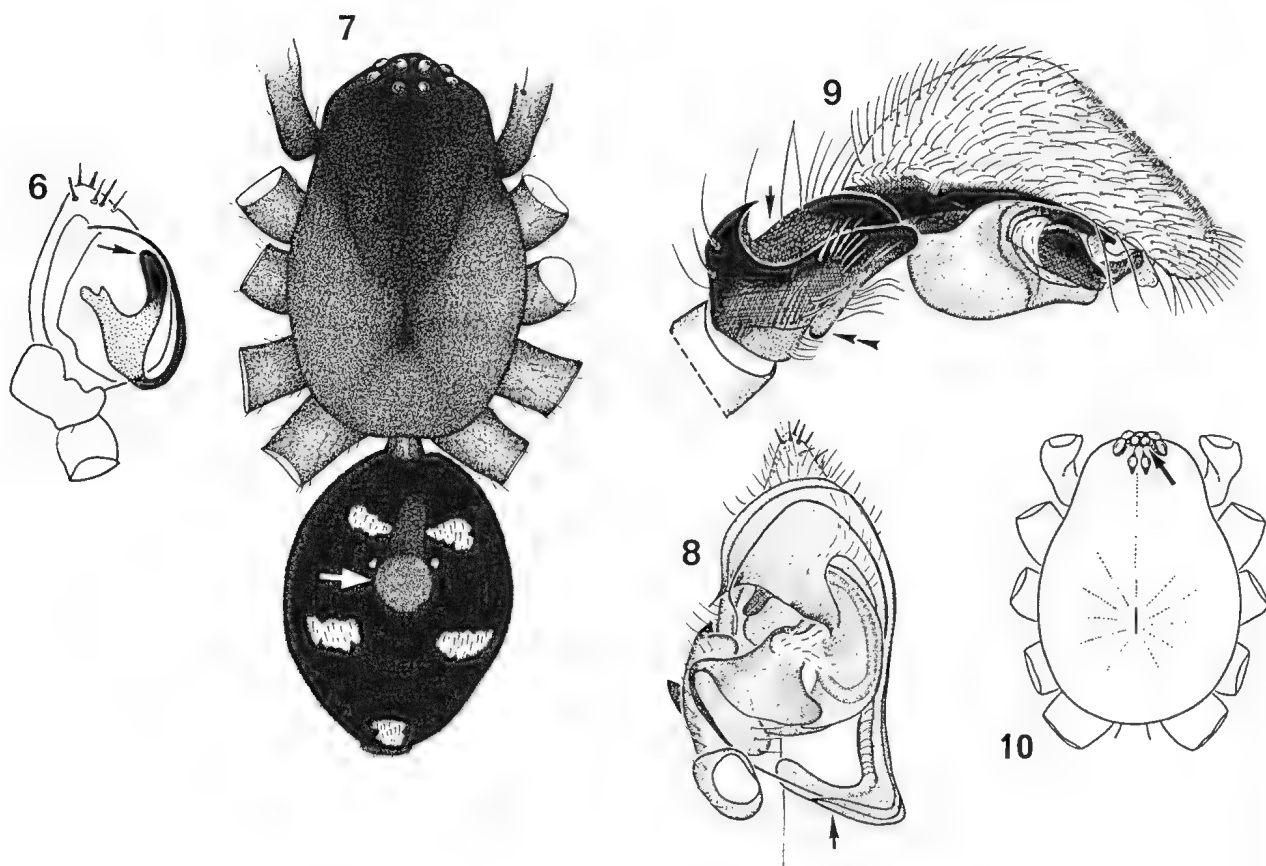


5. Chilum double (Fig. 5a); cymbial fold, which opens ventrally, converges into a pointed "exit" (Fig. 5c); tegulum with double apophysis: one sclerotised, more or less straight, lying ventrad of a membranous one which is similar in form but less slender..... *Neostorena*

- Chilum single (Fig. 5b); lateral fold opens to the side, without pointed exit ..... 6







6. Tegulum Y-shaped due to a curved sclerotised mesal excrescence (Fig. 6); tegulum with a distal membranous appendage; abdomen without row of short spines in front of tracheal opening ..... *Habronestes*
- Tegulum of usual shape, with sclerotised appendages; row of short spines in front of tracheal opening ..... *Mallinella*
7. Abdomen in the middle of dorsum with finely pitted shield in between three or five pale white dorsal spots (Fig. 7) ..... *Storena*
- Abdomen in male sometimes with frontal scutum but without pitted shield ..... 8
8. Tegulum with large, free-standing tegular apophysis developed in opposite direction of embolus (Fig. 8) (sometimes much smaller than on drawing) ..... *Asteron*
- Tegular apophysis appressed against tegulum and developed in same direction as embolus ..... 9
9. Male palpal tibia with dorsal concavity (Fig. 9) and ventral knob (Fig. 9); tegular apophysis small and membranous, embolus massive ..... *Storosa*

- Male palpal tibia and tegulum without these characters ..... 10
10. Tegument of carapace strongly and deeply reticulated; chelicerae without teeth ..... 11
- Tegument of carapace smooth or finely granulated; chelicerae with 1 or 2 promarginal teeth ..... 12
11. Margin of clypeus with central concavity accommodating high double chilum (width/height c. 1) ..... *Chilumena*
- Margin of clypeus straight (Fig. 5a), chilum lower (width/height c. 3) ..... *Zillimata*
12. AME the smallest; MOQ more than 1.5 times longer than wide (Fig. 10); sternum rebordered; male chelicerae swollen at base ..... *Australorena*
- Eyes subequal; MOQ less than 1.5 times longer than wide; sternum not rebordered; male chelicerae normal ..... *Nostera*

### Taxonomy

#### Lachesaninae Jocqué

#### *Australutica* n.gen.

**Diagnosis.** Members of this genus are recognised by the combination of characters of the subfamily Lachesaninae (retractile AS, ovoid sternum) combined with the presence of two rows of long spines on the anterior metatarsi.

**Etymology.** This generic name is a contraction of Australia and *Lutica*, another genus in the Lachesaninae.

### Description

Medium-size to large spiders (5.0–14.0 mm) with oval carapace, widest between coxae II and III and narrowed in front to about 0.6–0.7 times maximum width in both sexes. Carapace smooth with clear cervical grooves and deep fovea; rather elongate (L/W c. 1.4 in ♂♂, c. 1.6 in ♀♀). Profile with strongly raised cephalic part. Highest point of profile between PME and fovea. Finely haired or without hairs. A few stronger setae around fovea and on clypeus.

Colour: prosoma, including legs, yellow to orange; cephalic area sometimes with darker pattern.

Eyes in two rows; both rows more or less strongly procurved. AME dark and circular, remainder pale and circular. AME the largest, other eyes of similar size. MOQ longer than wide (up to 1.3 times) or subquadrangular. Clypeus straight, slightly retreating or slightly bulging; about 3 times as high as the diameter of an ALE. Chilum a wide, thinly haired sclerite, 4 to 5 times wider than high. Chelicerae normal; densely haired in front; with strong lateral condyle; anterior margin with one (♂) or two teeth (♀). Fangs rather long; length about three times width at base.

Endites roughly rectangular, tapering towards extremity and with basolateral extension, slightly converging, with dense anteromesal scopula.

Labium roughly rectangular, narrowed in front and at base, 1.2 to 1.4 times longer than wide. Sternum oval, without lateral extensions but with very small extensions between coxae.

Leg formula 4123 or 4312. Spination: number of spines very variable, always fewer on legs I and II than on posterior pairs of legs but Mt I and II with 2 rows of ventral spines which may be short. Femora in males with dense cluster of ventral hairs. Hinged hairs present on T and Mt. Tarsi with spiniform scopulae. No claw tufts. Three claws; paired claws with oblique row of teeth, varying between 8 on anterior and 18 on posterior tarsi; the most proximal teeth are implanted in the axis of the claw, the most distal ones clearly laterally, facing the other claw. Trichobothria in two dorsal rows on tibia, in a dorsal and a retrolateral row on Mt, and in a dorsal row on tarsi.

Abdomen oval without or with faint but complex pattern. Epiandrum poorly developed. Six spinnerets, surrounded by long, curved hairs; anterior pair long, retractable, cylindrical, clearly bi-articulate, with few (♂) or many (♀) large spigots. Posterior spinnerets only about half the length of the AS, cylindrical, faintly bi-articulate. Median pair conical, small in females, very small in males. Colulus represented by two groups of short setae. Tracheal spiracle narrow, with sclerotised rim.

Male palp with long tibial apophysis, usually widened at extremity. Cymbium with several strong distal spines and a basolateral flange. Embolus variable in length and direction; originating on promesal margin part of tegulum, very thin, reaching anterior tip of membranous tegular apophysis, here serving as conductor.

Female palp with long cylindrical tarsus and large toothed claw, turned inwards over c. 15°.

Epigyne quite simple with central entrance holes and widely separated large spermathecae.

**Type species.** *Australutica moreton* n.sp. (♂).

**Other species included.** *Australutica manifesta* n.sp. (♂) *Australutica quaerens* n.sp. (♂) *Australutica xystarches* n.sp. (♀); a few undescribed species.

**Affinities.** According to the definition of the Lachesaninae (Jocqué, 1991), *Australutica* belongs in that subfamily. It has the typical features (ovoid sternum, simple palpal conformation, eyes in two procurved rows, claw teeth in oblique row, endites with basolateral extension) of the subfamily including its single synapomorphy, that is its retractile AS. It can be questioned though whether the species here described do belong in one and the same genus. Since the taxonomy of the Zodariidae is for a large part based on palpal morphology, it would seem that *A. quaerens* should be placed in another genus. The conformation of its palp is indeed quite different from that of *A. moreton*. Mainly the fact that the embolus is coiled in the reverse direction, clockwise on the right palp, is a strong indication that *A. quaerens* represents a separate evolution line.

A solution to this problem awaits discovery of the alternate sex of at least a few of the species now placed in *Australutica*.

### *Australutica moreton* n.sp.

Figs 11a–d, 12a,b

**Type material.** HOLOTYPE ♂: Australia, Moreton Island, Bulwer Swamp, 30 September 1982, W. Houston (QM S 12159). PARATYPES: 2♂♂: together with holotype (1♂ in KBIN).

**Diagnosis.** The male of this species is recognised by the abdominal and cephalothorax pattern, by the shape of the male palpal tibial apophysis which is gradually tapered to a sharp tip.

**Etymology.** *Moreton* is a noun in apposition taken from the type locality.

### Description

**Male** (paratype measurements in brackets): total length 6.73 (5.53, 6.26) mm; carapace 3.45 (2.90, 3.49) mm long, 2.34 (1.87, 2.26) mm wide. Colour (Fig. 11a): carapace yellow with V-shaped pattern in front of fovea, clypeus and lateral sides of cephalic area dark. Chelicerae yellowish orange; sternum yellow; legs yellow, femora darkened. Abdomen with typical dorsal pattern (Fig. 11a). Venter with yellow epandrium; remainder white except dark area around spinnerets.

Eyes: a, 0.16; b, 0.12; c, 0.11; d, 0.11; e, 0.05; f, 0.04; g, 0.11; h, 0.17. MOQ, AW = 1.15×PW; AW = 1.02×L.

Legs: measurements and spination are given in Tables 1 and 2. Femora III and IV with dense group of pro- and retroventral hairs.

Palp: see Fig. 12a,b.

**Female.** Unknown.

**Other material examined.** None.

**Distribution.** Known only from the type locality, Moreton Island.

### *Australutica manifesta* n.sp.

Fig. 12d–f

**Type material.** HOLOTYPE ♂: South Australia, Dalhousie, 26°34'S 137°21'E, 27 August 1991, sand plain, W. Head (SAMA ARA 5323). PARATYPES: 1♂: South Australia, Maralinga, 12 km south-south-west, 30°16'S 131°33'E, 10–15 October 1987, sand dune, *Myoporum* vegetation, pitfall, Yellabina Survey (SAMA 5323); 2♂♂: South Australia, Purni Bore, 26°17'S 136°06'E, 24–29 August 1991, H. Ehmann (SAMA ARA 5323, 1♂ in KBIN).

**Diagnosis.** The male of this species is recognised by the abdominal pattern with two rows of small transversal stripes, by the shape of the male palpal tibial apophysis, which has a broad base with almost parallel sides and the tip of which the inferior margin is concave. The species is obviously strongly related to *A. moreton*.

**Etymology.** The word *manifesta* (Latin *manifestus* = evident) refers to the fact that this is a very typical representative of the genus.

### Description

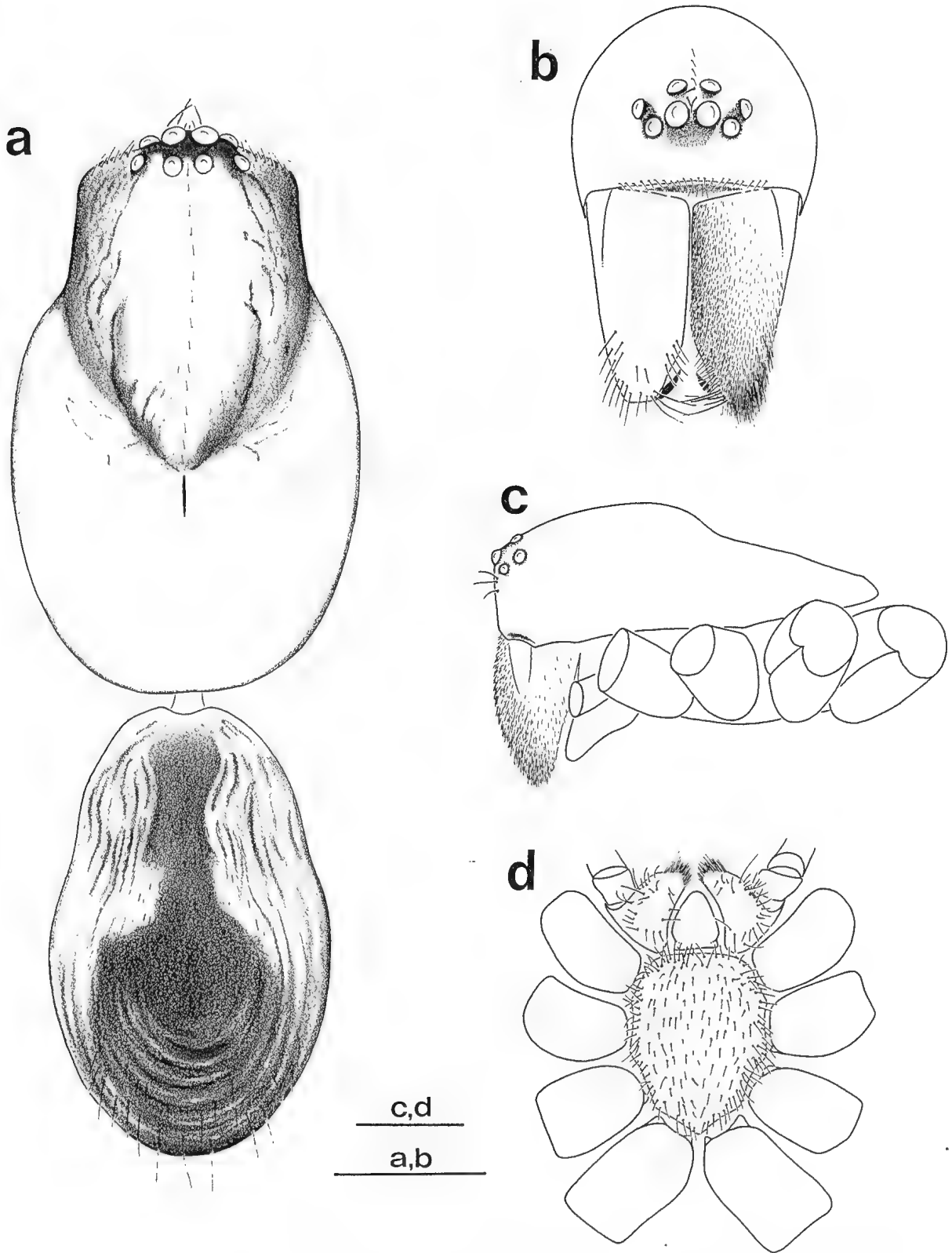
**Male** (paratype measurements in brackets): total length 8.70 (7.57–10.44) mm; carapace 4.26 (4.17–5.04) mm long, 3.04 (3.04–3.39) mm wide. Colour: carapace pale yellow, darker in cephalic area (Fig. 12d). Chelicerae yellow. Sternum pale yellow; legs pale yellow, Mt and t slightly darker. Abdomen very pale with typical dorsal pattern consisting of narrow central dark area in front, followed by two rows of six small transverse stripes. Venter with yellow epandrium; remainder white.

Eyes: a, 0.21; b, 0.11; c, 0.15; d, 0.17; e, 0.04; f, 0.07; g, 0.11; h, 0.27. MOQ, AW = 1.09×PW; AW = 0.96×L.

Legs: Tarsi III and IV slightly curved upwards. Leg measurements and spination are given in Tables 1 and 2. Femora II, III and IV with dense group of pro- and retroventral hairs, groups denser and setae more rigid from II towards IV.

Palp: see Fig. 12e,f.

**Female.** Unknown.



**Fig. 11.** *Australutica moreton* n.sp. **a**, habitus; **b**, carapace, frontal view; **c**, carapace, lateral view; **d**, sternum, labium and endites. Scales 1 mm.

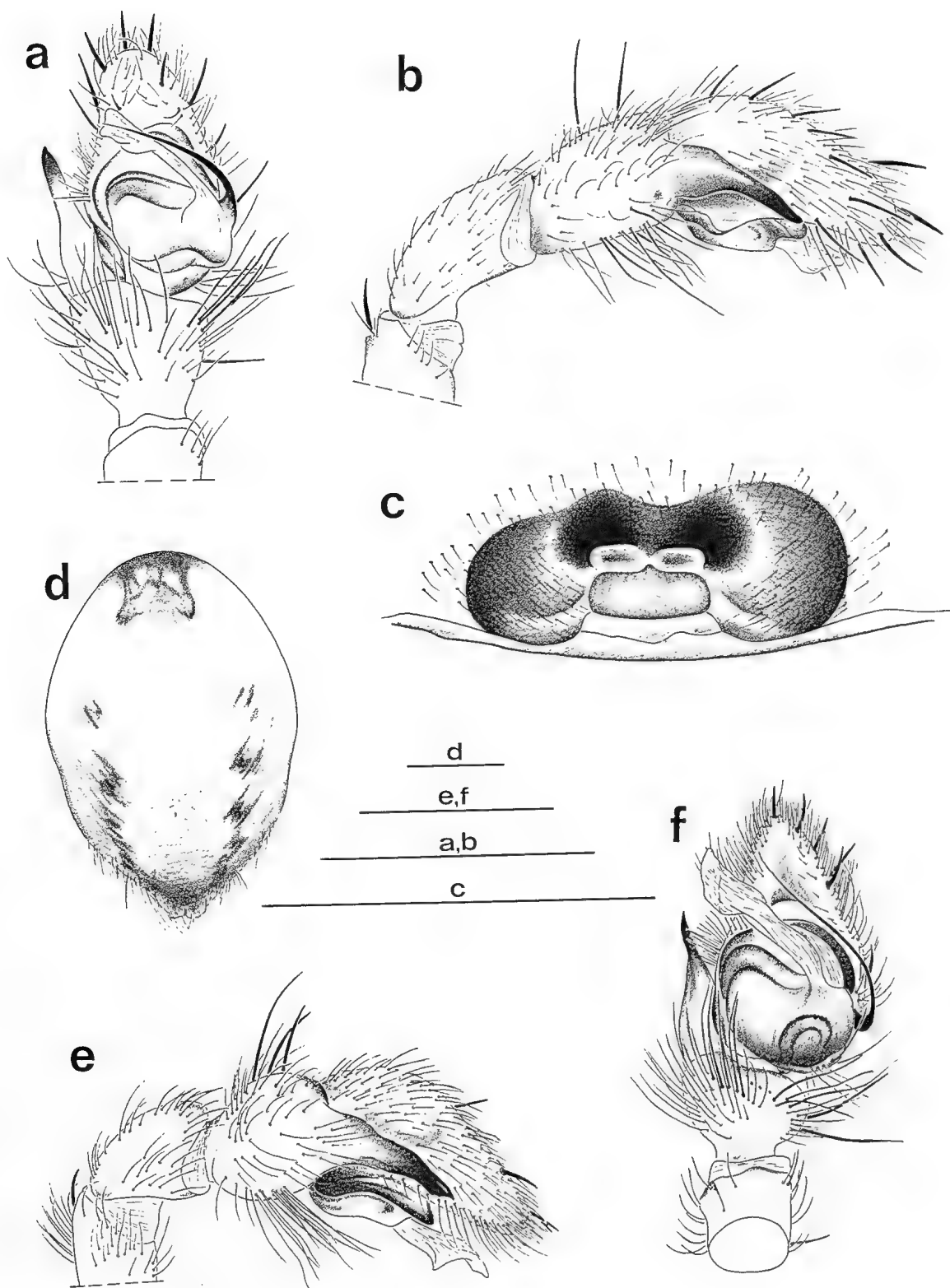


Fig. 12. *Australutica moreton* n.sp. a, male palp, ventral view; b, lateral view. *Australutica xystarches* n.sp. c, epigyne. *Australutica manifesta* n.sp. d, abdomen, dorsal view; e, male palp, lateral view; f, male palp, ventral view. Scales 1 mm.

**Other material examined.** None.

**Distribution.** South Australia.

*Australutica xystarches* n.sp.

Fig. 12c

**Type material.** HOLOTYPE ♀: Australia, South Australia, Lake Hart, 31°10'S, 136°25'E, under fallen fence posts on surface of lake, 24 June 1989, N.A. Locket (SAMA ARA 5323). PARATYPE: 1 subadult ♂, with same label-data as holotype.

**Diagnosis.** The species is so far the largest of the genus and the only one for which the female is known.

**Etymology.** The name is a noun in apposition; *xystarches* (Greek) meaning "leader of sport activities" and refers to the robust appearance of the specimens.

**Description**

**Female.** Total length 11.13 mm; carapace 5.92 mm long, 3.56 mm wide. Colour: prosoma including legs entirely yellow. Chelicerae and labium medium brown; sternum orange in front fading to yellow behind. Abdomen uniform pale greyish yellow.

Eyes: a, 0.20; b, 0.20; c, 0.15; d, 0.20; e, 0.08; f, 0.12; g, 0.13; h, 0.30. MOQ, AW = 1.11×PW; AW = 0.94×L.

Leg measurements and spination are given in Tables

1 and 2. Femora without groups of pro- and retroventral hairs.

Epigyne: see Fig. 12c.

**Male.** Only subadult male known; larger than female. Total length 14.79 mm; carapace 6.09 mm long, 3.65 mm wide. Otherwise very similar to female.

**Other material examined.** None.

**Distribution.** Known only from the type locality, Lake Hart, South Australia.

*Australutica quaerens* n.sp.

Fig. 13a,b

**Type material.** HOLOTYPE ♂: Australia, South Australia, Loxton, 22.5 km south-west, 34°33'S 140°22'E, 28 May 1991, pitfall, A.J. McArthur (SAMA ARA 5323). PARATYPES: 3♂♂; with same label-data as holotype (1♂ in KBIN).

**Diagnosis.** The male of this species is recognised by the abdominal and cephalothorax pattern, by the shape of the male palpal tibial apophysis and by the complex bulbus with embolus turning clockwise in right palp which is unusual in the family.

**Etymology.** The word *quaerens* is from the Latin *quaerere* which means "to search" referring to the doubtful attribution of this species to the genus *Australutica*.

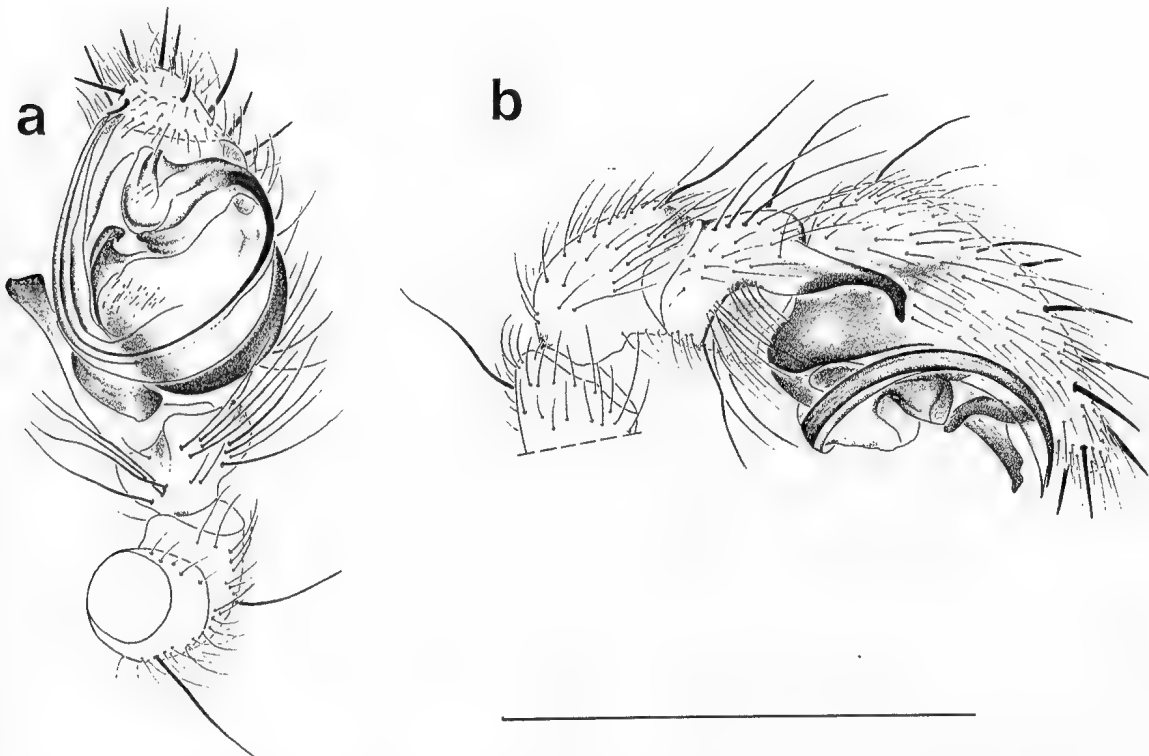


Fig. 13. *Australutica quaerens* n.sp. a, male palp, ventral view, b, lateral view. Scale 1 mm.

### Description

**Male** (paratype range in brackets): total length 4.77 (4.90–5.32) mm; carapace 2.60 (2.34–2.73) mm long, 1.62 (1.58–1.66) mm wide. Colour: carapace pale yellow with V-shaped pattern in front of fovea, darker yellow in cephalic area. Chelicerae brownish yellow; sternum yellow darkened to orange on sides; legs yellow, femora slightly paler than remainder of legs. Abdomen with typical dorsal pattern: consisting of a dark sepia stripe on pale background: stripe wide in front, narrowed then widened near the centre to large chevron, narrowed again, finally ending in chevrons which are interrupted in the middle. Venter with pale, poorly developed epiandrum, remainder and spinnerets pale.

Eyes: a, 0.11; b, 0.11; c, 0.10; d, 0.11; e, 0.053; f, 0.03; g, 0.05; h, 0.09. MOQ,  $AW = 1.00 \times PW$ ;  $AW = 0.80 \times L$ .

Leg measurements and spination are given in Tables 1 and 2. Femora without dense ventral groups of hairs.

Palp: see Fig. 13a,b.

**Female.** Unknown.

**Other material examined.** None.

**Distribution.** Known only known from the type locality, Loxton, South Australia.

### Zodariinae Simon

#### *Australorena* n.gen.

**Diagnosis.** Representatives of *Australorena* are recognised by the small AME, the elongate MOQ and the flat carapace; males by the swelling of the chelicerae, the rebordered sternum and the ventral single row of strong spines on tibia II; male palp with an anterior, a median and a posterior lateral apophysis; females by the large touching spermathecae near the posterior margin.

**Type species.** *Habronestes scenicus* Koch.

**Affinities.** The type species of this new genus has several somatic features in common with *Hetaerica aresca*, the only species of *Hetaerica*, known only from a juvenile specimen. The main resemblance is the size of the AME and the shape of the MOQ which match. Both species might thus well be congeneric but as the majority of the Australian genera is based on characters of the genitalia, *Hetaerica* is likely to remain *incertae sedis*. *Australorena* is probably the sister-group of *Storosa* with which it shares the general shape of the carapace, the double chilum and the dorsolateral concavity of the male palpal tibia; the vulva is also very similar with entrance ducts opening in front and spermathecae touching, situated near the posterior margin. Important differences are the differences in the eye arrangement and the absence of a ventrolateral knob on the male palpal tibia as well as the tegular apophysis and membrane in the palp of *Australorena*.

**Etymology.** *Australorena* is a contraction of Australia and *Storosa*. The gender is feminine.

**Description.** Medium-size spiders (7.0–13.0 mm). Carapace fairly low and level, in profile hardly raised in front; widest point at the level of coxae II; narrowed in front to about 0.5 (males) or 0.6 times the maximum width. Tegument reticulate with faintly marked median groove between eyes and fovea; without hairs. Clypeus retreating. Colour: prosoma dark reddish brown with sternum and legs somewhat paler. Abdomen dark sepia with simple pale pattern. Eyes in a close group, in two strongly procurved rows; the ALE can be considered a third row in front of both the others; AME dark, remainder pale and circular, subequal. AME the smallest. MOQ longer than wide (c. 1.7 times). Clypeus about three times as high as the diameter of an ALE, slightly convex and retreating. Chilum a high, double sclerite, width/height ratio of each triangle >3. Chelicerae in males with lateral swelling or frontal boss at about half their length; not haired; one or two teeth on promargin. Fangs short and broad. Endites strongly converging; with distomesal scopula. Labium triangular with narrowed base. Sternum triangular, truncated in front; rebordered laterally; in males more strongly so towards back; rebordering less strong in females. Without lateral excrescences or intercoxal sclerites. Legs: formula 4123. Coxae strongly bulging in males, overhanging sternum; less strongly bulging in females. Spination: males with T I with a row or without spines, T II with a row of 3 to 5 ventral spines; in females T I spinate and not more than 2 ventral spines on T II. Mt I and II with some short ventral spines; posterior leg pairs with numerous spines. Tarsal scopula spiniform. Mt II–IV distally swollen and with distoventral group of hairs. Hinged hairs present. Superior pair of tarsal claws with 9–12 lateral teeth. Trichobothria in two rows on T and Mt, in one row on t. Hinged hairs few on anterior leg pairs. Abdomen oval, without scutum; with two poorly developed muscle apodemes. Six spinnerets, median and posterior pairs small, slightly larger in females than in males. Colulus represented by a few setae. Tracheal spiracle narrow, semicircular, procurved, just in front of spinnerets. Epiandrum present. Male palp: tibia prolaterally concave, with three ventrolateral or lateral apophyses; without ventrolateral back-pointing knob. Cymbium with elongate flange. Embolus broad or slender, originating posterolaterally on tegulum which is extended in front into a wide, curved, conductor-like appendage or long apophysis, which has a central membranous part. Female palp with elongate and tapering tarsus, claw turned inwards over c. 30°.

**Other species included.** One undescribed from Lake Broadwater, Queensland.

**Distribution.** Queensland and New South Wales.



*Australorena scenica* (Koch) n.comb.

Figs 14a–d, 15a–d

*Habronestes scenicus* Koch, 1872: 301, 316 (description of ♂).  
*Storena scenica*.—Simon, 1893: 427.—Rainbow, 1911: 151.—  
 Davies, 1985: 121.

**Type material examined.** HOLOTYPE ♂: Australia, Queensland, Bowen (MZH).

**Diagnosis.** Males are recognised by the scopula on F III, the relatively short embolus and tegular apophysis.

**Description**

**Male.** Total length 6.66 mm; carapace 3.53 mm long, 2.51 mm wide.

Colour: type specimen bleached; fresh specimens have dark reddish brown carapace, reddish brown chelicerae and sternum with darker rebordered margins; legs with dark reddish brown femora and patellae with paler dorsal and retrolateral stripes, reddish brown coxae and yellowish brown tibia, metatarsi and tarsi; abdomen dark sepia, dorsum with two parallel series of longitudinal pale spots and one spot in front of spinnerets, sometimes united to large central pale patch (Fig. 14a); venter dark sepia with three longitudinal pale patches. Chelicerae laterally bulging near middle; anterior margin with one tooth.

Eyes: a, 0.06; b, 0.13; c, 0.13; d, 0.12; e, 0.05; f, 0.07; g, 0.03; h, 0.12; AL-AL, 0.14. MOQ, AW =  $0.61 \times \text{PW}$ ; AW =  $0.53 \times \text{L}$ . Clypeus straight, 0.42 high or 3.2 times the diameter of an ALE.

Leg measurements and spination are given in Tables 1 and 2. Hinged hairs: T I and II,  $d1r/l$ ; Mt I and II,  $d1$ . Femora III with ventral scopula.

Male palpus: Fig. 15a,b. Distal narrowed part of tegulum with many, tiny teeth. Embolus rather slender, distally hidden.

**Female.** Total length 8.46 mm; carapace 3.58 mm long, 2.37 mm wide.

Colour: as in the male; abdominal ventral pattern with only two faint longitudinal pale stripes. Chelicerae laterally not bulging. Anterior margin with one tooth.

Eyes: a, 0.10; b, 0.14; c, 0.12; d, 0.15; e, 0.05; f, 0.12; g, 0.05; h, 0.12; AL-AL, 0.12; MOQ, AW =  $0.78 \times \text{PW}$ ; AW =  $0.62 \times \text{L}$ . Clypeus straight, 0.40 high or 2.9 times the diameter of an ALE.

Leg measurements and spination are given in Tables 1 and 2. Hinged hairs as in male. Femora III without scopula.

Epigyne (Fig. 15c,d): simple, with shallow longitudinal central depression ending in entrance opening, situated near anterior margin; structures of vulva (Fig. 15c) shining through; two large entrance copulatory ducts converging towards spermathecae situated near posterior margin.

Variation. Male total length 6.04–6.69 mm; carapace length 2.93–3.35 mm; width 2.14–2.28 mm. The number of ventral spines on Mt II may vary from 1-2-2 to 1-2-1-3; on T II from 3\* to 5\*. Female total length 6.04–8.46 mm; carapace length 2.79–3.58 mm; width 1.86–2.37 mm.

**Other material examined.** QUEENSLAND (2JJ): Brisbane, Rochedale State Forest, (QM S3729); 1J (QM S3719); 1J (QM S4344); 1J, 1K & 1 juvenile: Homevale, 6 April 1975, sclerophyll woodland near creek, with ants *Rhytidoponera* (QM S3681); 7JJ, 3KK & 4 juveniles: 40 Mile Scrub, south-west Mount Garnet, 10 April 1978, males pitfalls, females litter, R. Raven & V. Davies (QM S4487); 19JJ, 2KK: Lake Broadwater, via Dalby, 25 February–22 April 1986, pitfalls, QM & M. Bernie, (QM S15735); 2KK: Lake Broadwater, via Dalby, 3 January–25 February 1986, pitfalls, QM & M. Bernie, (QM S15727); 1J, 1K: Bluff Downs, 95 km north-west Clarkin Towers, in ground, 19 April 1974, Archer & Elliott (QM S4354); 2JJ: Wongabel, 8 km south of Atherton, 21 January 1989, malaise trap, A. & H. Howden (AM KS27935).

**Distribution.** Eastern Queensland, Australia.

*Chilumena* n.gen.

**Diagnosis.** Representatives of *Chilumena* are recognised by the deep reticulation of the carapace and the concavity of the clypeus accommodating the chilum.

**Affinities.** The genus is apparently strongly related to *Storosa* with which it shares the high double chilum and the structure of the palp. It shares the deep reticulation of the carapace with *Zillimata* but in that genus there is no clypeal concavity and the embolus runs clockwise on the right palp, which is very unequal and so far only found in *Australutica quaerens*.

**Etymology.** *Chilumena* is a contraction of *chilum* and *Storena* and refers to the importance of the size of the chilum which is accommodated in a concavity of the clypeus. The gender is feminine.

**Description.** Medium-size spiders (5.0–7.0). Carapace domed, without cervical grooves; profile sharply falling from cephalic area towards posterior margin. Widest point between coxae II and III; sides parallel, hardly narrowed in front. Tegument deeply reticulated and with faint metallic lustre, finely haired. Colour: prosoma reddish brown with sternum and legs somewhat paler. Abdomen sepia with simple pale pattern. Eyes in a close group, in two strongly procurved rows; the ALE can be considered a third row in front of both the others; AME dark, remainder pale and circular, subequal. AME the largest. MOQ longer than wide (c. 1.2 times). Clypeus strongly retreating, 4 to 5 times as high as the diameter of an ALE. With central concavity accommodating chilum. Chilum high, double, width/

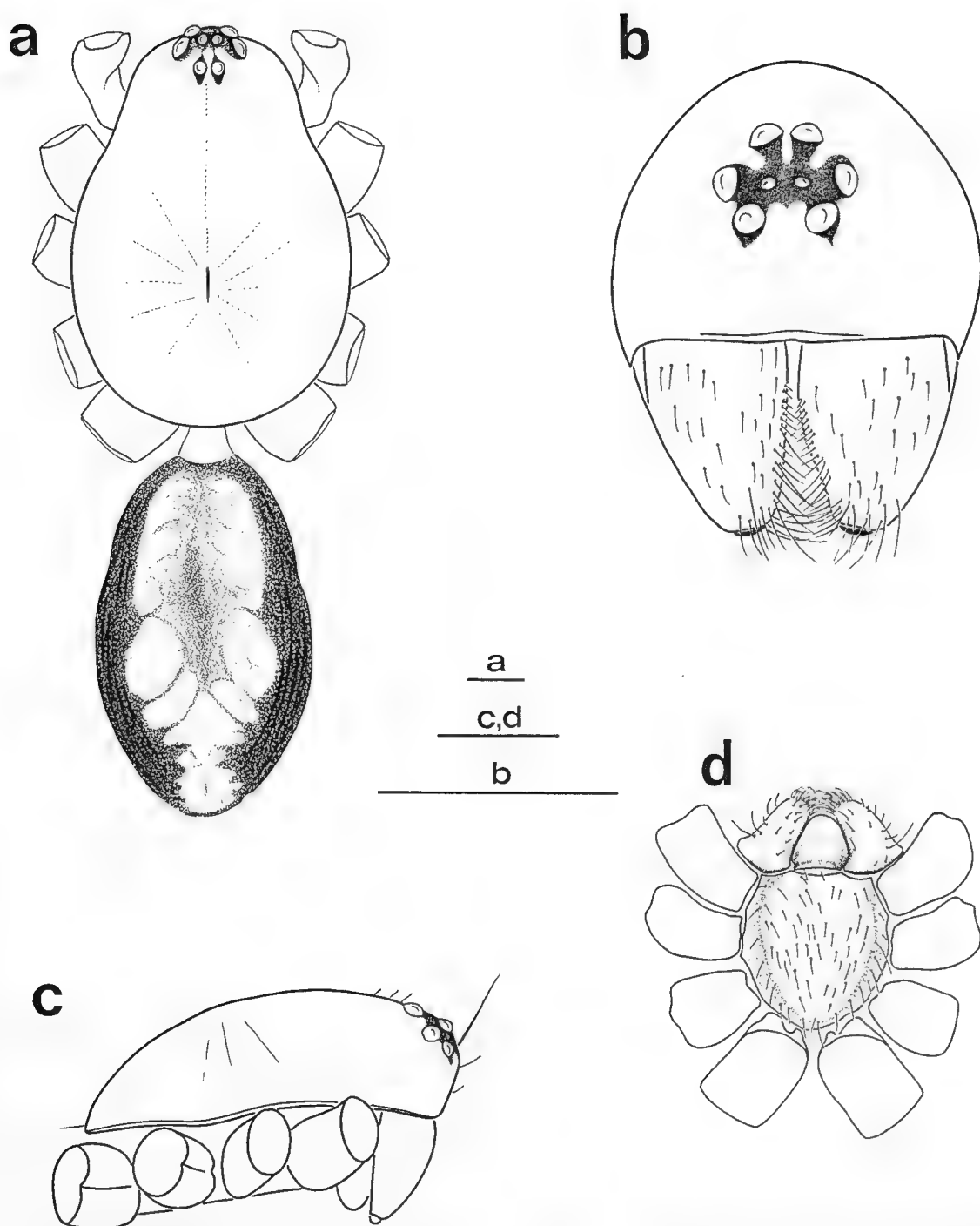


Fig. 14. *Australorena scenica* (Koch) a, habitus; b, carapace, frontal view; c, carapace, lateral view; d, sternum, labium and endites. Scales 1 mm.

height ratio of each triangle c. 1. Chelicerae slender, lateral condyle extended into lateral ridge; without teeth. Fangs short and broad. Endites strongly converging; with poorly developed distomesal scopula. Labium triangular with base hardly narrowed. Sternum triangular, truncated in front; slightly longer than wide. Small triangular extensions fitting in coxal concavities and small intercoxal extensions.

Legs formula 1423. Tarsi of leg I considerably longer than those of other legs. Tarsi cylindrical slightly widened towards extremity. Coxae strongly bulging in males, overhanging sternum; less strongly bulging in females. Spination: few spines on anterior legs, more numerous on posterior pairs. Tarsal scopula spiniform. Mt II–IV distally swollen and with distoventral group of supposedly chisel-shaped hairs. Hinged hair present

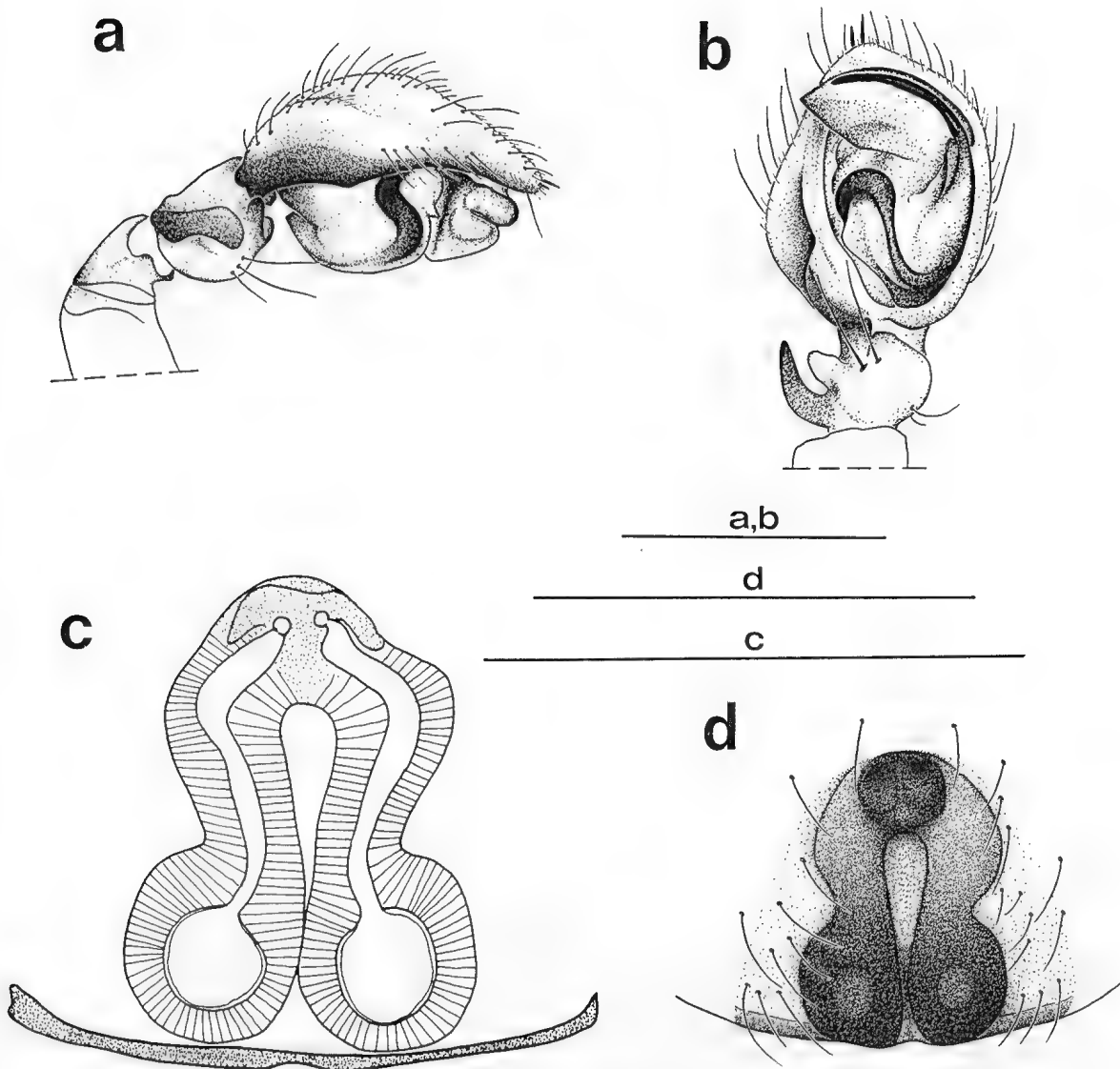


Fig. 15. *Australorena scenica* (Koch) a, male palp, lateral view; b, male palp, ventral view; c, epigyne, cleared, dorsal view; d, epigyne, ventral view. Scales 1 mm.

on T I. Superior pair of tarsal claws with 8–10 lateral teeth. Trichobothria in two rows on T, in one row on Mt and t. Abdomen oval, with narrow scutum in male, without scutum in ♀; with two poorly developed muscle points. Six spinnerets in female, only four in males or median pair very small. Colulus represented by a few setae. Tracheal spiracle narrow, just in front of spinnerets. Epiandrium present.

Male palp. Tibia with dorsolateral apophysis; ventrally with two shallow ridges separated by a membranous cleft. Embolus short and broad, originating posterolaterally on tegulum which is extended in front into a slender, spine-shaped, conductor-like appendage; other extremity of tegulum with hook-like apophysis on membranous support, converging with distal conductor. Female palp with strongly tapering almost conical tarsus, claw turned inwards over c. 30°. Epigyne a simple triangular plate with central membranous part.

**Type species.** *Chilumena reprobans* n.sp.

**Other species included.** *Chilumena baehrorum* n.sp.

**Distribution.** South-east Queensland, Western Australia, Northern Territory.

*Chilumena reprobans* n.sp.

Fig. 16a–f

**Type material.** HOLOTYPE ♂: Western Australia, Wyndham, 15°30'S 128°09'E, 20 October 1962, E. Ross & D. Cavagnaro (CAS).

**Diagnosis.** The male of this species is recognised by the shape of the male apophysis and of the tegular appendages.

**Etymology.** *Reprobans* (Latin for rejecting) refers to the impossibility to include this species in the same genus as *Zillimata scintillans*.

### Description

**Male.** Total length 5.62 mm; carapace 3.06 mm long, 1.79 mm wide.

Colour: carapace, chelicerae and sternum uniform reddish brown with faint metallic hue; legs orange with pale ring on extremity of first tibia. Abdomen pale sepia, dorsum with five transversal bars, two in front, two in the middle and one above the spinnerets; a narrow pale brown scutum in between the anterior pair of bars, lateral sides with large pale spot in front, above epigastric fold. Sparsely covered with fairly long, rigid, dark brown setae. Carapace strongly reticulated.

Eyes: a, 0.20; b, 0.15; c, 0.15; d, 0.17; e, 0.02; f, 0.06; g, 0.10; h, 0.22. MOQ,  $AW = 1.05 \times PW$ ;  $AW = 0.87 \times L$ . Clypeus 0.62 mm high or 4.1 times the diameter of an ALE.

Leg measurements and spination are given in Tables 1 and 2. Femora densely granulated.

Male palpus: see Fig. 16e,f.

**Female.** Unknown.

**Other material examined.** None.

**Distribution.** Known only known from the type locality, Wyndham, Western Australia.

### *Chilumena baehrorum* n.sp.

Fig. 16g

**Type material.** HOLOTYPE ♀: c. 125 km N of Hall's Creek, 17°30'S 127°40'E, 5 November 1984, M. & B. Baehr (WAM).

**Diagnosis.** The female of this species is recognised by the central triangular membranous structure in the epigyne.

**Affinities.** Although the coloration and habitus of this species is very similar to those of *C. reprobans* this female is considered to belong to another species on the base of the differences in eye position and spination.

**Etymology.** *Baehrorum* is a patronym in honour of Barbara and Martin Baehr who collected the type specimen, in esteem for their fieldwork in Australia.

### Description

**Female.** Total length 6.90 mm; carapace 3.41 mm long, 1.92 mm wide.

Colour: carapace, chelicerae and sternum uniform reddish brown with faint metallic hue; legs orange with

pale ring on extremity of first tibia. Abdomen pale sepia, dorsum with five transversal bars, two in front, two in the middle and one above the spinnerets; lateral sides with large pale spot in front, above epigyne; venter with large uniform sepia triangle between epigyne and spinnerets, remainder mottled. Carapace strongly reticulated. Entire abdomen sparsely covered with fairly long, rigid, dark brown setae.

Eyes: a, 0.18; b, 0.14; c, 0.16; d, 0.15; e, 0.03; f, 0.10; g, 0.13; h, 0.15. MOQ,  $AW = 0.89 \times PW$ ;  $AW = 0.70 \times L$ . Clypeus 0.75 high or 5.3 times the diameter of an ALE.

Leg measurements and spination are given in Tables 1 and 2. Femora finely granulated.

Epigyne (Fig. 16g): membranous centre in the shape of an inverted triangle with concave lateral sides.

**Male.** Unknown.

**Other material examined.** None.

**Distribution.** Known only from the type locality, Hollow Creek, Northern Territory.

### *Zillimata* n.gen.

**Diagnosis.** Representatives of *Zillimata* are recognised by the deep reticulation of the carapace in the absence of a concavity of the clypeus accommodating the chilum; the embolus is directed in a clockwise direction in the right palp.

**Affinities.** The genus is very similar to *Chilumena* as far as its habitus is concerned, it shares the deep reticulation of the almost parallel-sided carapace but lacks the concavity of the clypeus margin accommodating the chilum. More important though is the difference in male palpal conformation. *Australutica quaerens* and *Z. scintillans* are the only zodariids with a clockwise directed embolus (in the right palp). This means that the long thin extremity of the embolus lies on the lateral side of the bulb.

**Etymology.** *Zillimata* is an arbitrary combination of letters. The gender is feminine.

### Description

Small to medium-sized spiders (5.0–10.0 mm). Carapace domed, without cervical grooves; profile gradually falling from cephalic area towards posterior margin. Widest point between coxae II and III; sides parallel, hardly narrowed in front. Tegument deeply reticulated and with metallic lustre, finely haired. Colour: prosoma dark chestnut brown with sternum and legs somewhat paler. Abdomen sepia with simple pale pattern. Eyes in a close group, in two strongly procurved rows; the ALE can be considered a third row in front of both the others; AME dark, remainder pale and circular, subequal. AME

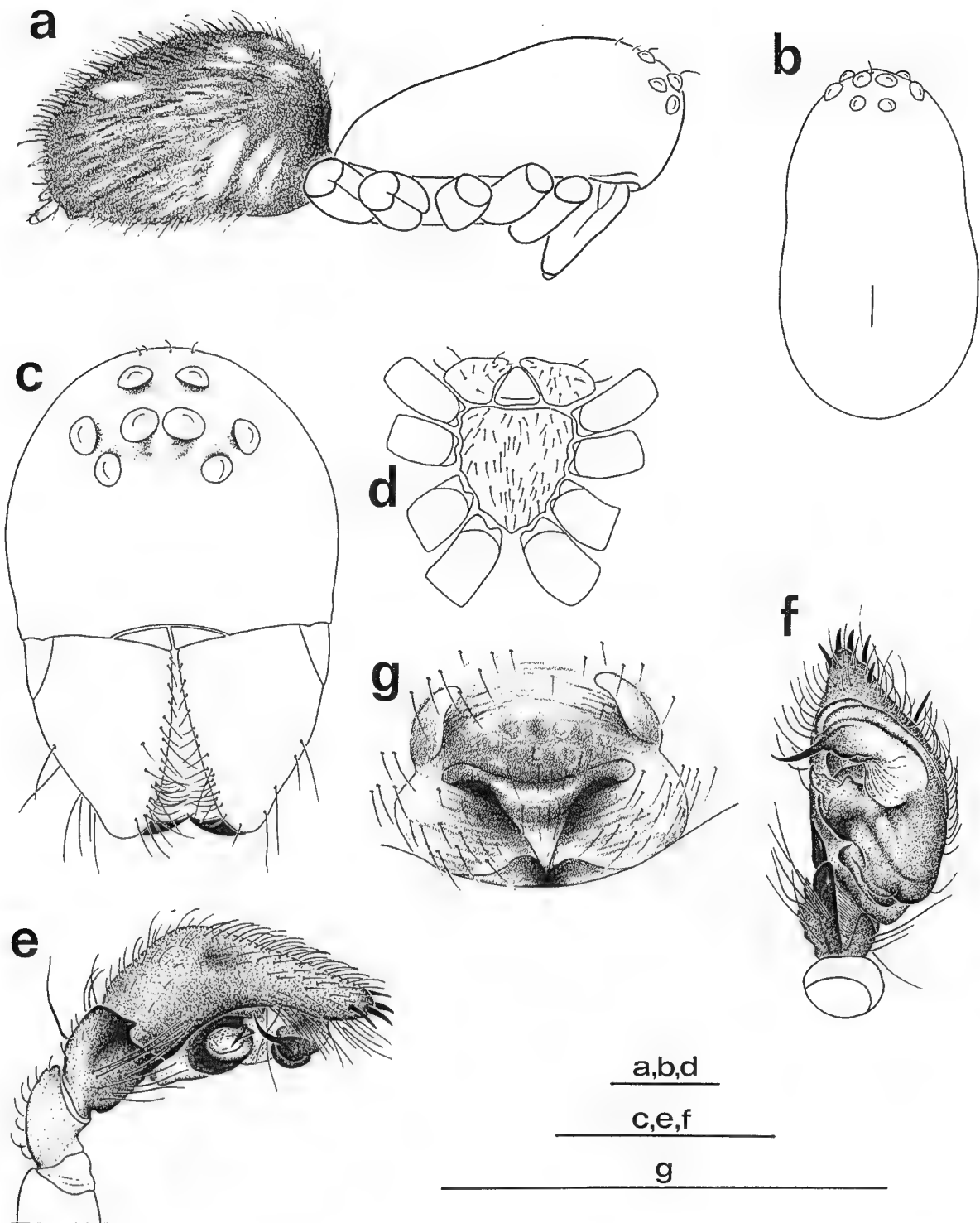


Fig. 16. *Chilumena reprobans* n.sp. a, habitus, lateral view; b, carapace, dorsal view; c, carapace, frontal view; d, sternum, labium and endites; e, male palp, lateral view; f, male palp, ventral view. *Chilumena baehrorum* n.sp. g, epigyne, ventral view. Scales 1 mm.

the largest. MOQ longer than wide (1.3–1.5 times). Clypeus strongly retreating, about 7 times as high as the diameter of an ALE. Without central concavity accommodating chilum. Chilum double, width/height ratio of each triangle c. 3. Chelicerae slender, lateral condyle extended into lateral ridge; without teeth. Fangs short and broad. Endites strongly converging; with poorly developed distomesal scopula. Labium triangular with base hardly narrowed. Sternum triangular, truncated in front; slightly wider than long. Small triangular extensions fitting in coxal concavities and small intercoxal extensions.

Leg formula 4123 or 1423. Tarsi fusiform. Coxae strongly bulging, overhanging sternum. Spination: few spines on anterior legs, more numerous on posterior pairs. Tarsal scopula spiniform. Mt II–IV distally swollen and with distoventral group of supposedly chisel-shaped hairs. Hinged hair present on T I. Superior pair of tarsal claws with 8–10 lateral teeth. Trichobothria in two rows on T, in one row on Mt and t. Abdomen oval, without scutum; with two poorly developed muscle points. Six spinnerets in female, only four in males or median pair very small. Colulus represented by a few setae. Tracheal spiracle narrow, just in front of spinnerets. Epiandrum present.

Male palp: tibia several small dorsolateral apophyses; ventrally with one ridge. Embolus long originating on promesal side of tegulum, running in clockwise direction on right palp so that slender end is laying on lateral side of palpus; distal extremity of tegulum near base of embolus with hook-shaped extension; basal end of tegulum with rounded plate-like base near which is inserted an elongate membrane serving as conductor. Female palp with tibia widened towards distal end and strongly tapering almost conical tarsus, claw turned inwards over c. 30°. Epigyne a simple triangular plate with central membranous part. Entrance ducts thick-walled, ending in large touching spermathecae situated at posterior margin of epigyne.

**Type species.** *Storena scintillans* Pickard-Cambridge.

*Zillimata scintillans* (Pickard-Cambridge) **n.comb.**

Fig. 17a–d

*Storena scintillans* Pickard-Cambridge, 1869: 54.—Rainbow, 1911: 151.—Davies, 1985: 121.

*Habronestes scintillans*.—Koch, 1872: 302, 303.—Hogg, 1896: 311, 322.

**Type material.** HOLOTYPE ♀: Australia, Western Australia, Swan river (UMO) (examined).

### Description

**Female** (holotype). Total length 5.63 mm; carapace 2.84 mm long, 1.71 mm wide.

Colour: carapace and chelicerae medium brown with strong bluish metallic sheen; sternum and legs pale brown, except distal third of T I and basal rings of Fe II–IV white. Abdomen: dorsum pale sepia with 5 white patches; two narrow transversal ones in front of the spinnerets; entire dorsum with dispersed shiny hairs; venter pale sepia with a butterfly-shaped pale pattern between epigyne and spinnerets. Carapace strongly reticulated. Femora granulated. Chilum well developed, double. Leg spines few and short on legs I and II, numerous and short on III and IV.

**Female** from Jerdacuttup. Total length 6.91 mm; carapace 3.07 mm long, 1.83 mm wide.

Colour: carapace and chelicerae dark brown with strong bluish metallic lustre; sternum and legs pale brown, further as holotype.

Eyes: a, 0.13; b, 0.10; c, 0.11; d, 0.12; e, 0.03; f, 0.07; g, 0.13; h, 0.24. MOQ,  $AW = 0.83 \times PW$ ;  $AW = 0.66 \times L$ . Clypeus 0.77 high or 7.0 times the diameter of an ALE.

Leg measurements and spination are given in Tables 1 and 2.

Epigyne (Fig. 17c,d) with butterfly-shaped central membranous area. Copulatory ducts start just in front of central area, run dorsad and forward to anterior margin of epigyne, thence back and inwards, out and forwards again, to turn finally backwards where to join large touching spermathecae near posterior rim.

**Variation among other females.** Total lengths 4.81–7.24 mm; carapace length range 2.39–3.19 mm, 1.45–1.87 mm wide. Female from Darlington has white femoral rings only on legs III and IV.

**Male.** Total length 4.86 mm; carapace 2.60 mm long, 1.49 mm wide.

Colour: as in female but with narrow dark brown dorsal in front of abdomen; ventral white pattern restricted to a triangle on either side of the epiandrum.

Eyes: a, 0.14; b, 0.09; c, 0.11; d, 0.11; e, 0.01; f, 0.05; g, 0.08; h, 0.18. MOQ,  $AW = 0.97 \times PW$ ;  $AW = 0.71 \times L$ . Clypeus 0.62 high or 7 times the diameter of an ALE.

Leg measurements and spination are given in Tables 1 and 2.

**Other material examined.** WESTERN AUSTRALIA: 1K, Jerdacuttup, 9 May 1989, A. Winchester, under limestone rock in paddock with ant (*Rhytidoponera* sp.) (WAM 90/271); 1K, Weomanie Rock, October 1981, R. MacMillan (WAM 90/392); 1K, Darlington, March 1978, G. Lowe (WAM 90/328); 1J, Darlington, 150 m, 5 September 1962, E. Ross & D. Cavagnaro (CAS); SOUTH AUSTRALIA: 2KK, Wanilla Forest Reserve, 28 March 1987, *Eucalyptus* plantation, D. Lee & D. Hirst (SAM ARA 5323); QUEENSLAND: 1K, south-east Queensland, Lake Broadwater via Dalby, 3 January–25 February 1986, pitfalls, QM & M. Bernie (QM S15724).

**Distribution.** Western Australia, South Australia and south-east Queensland.

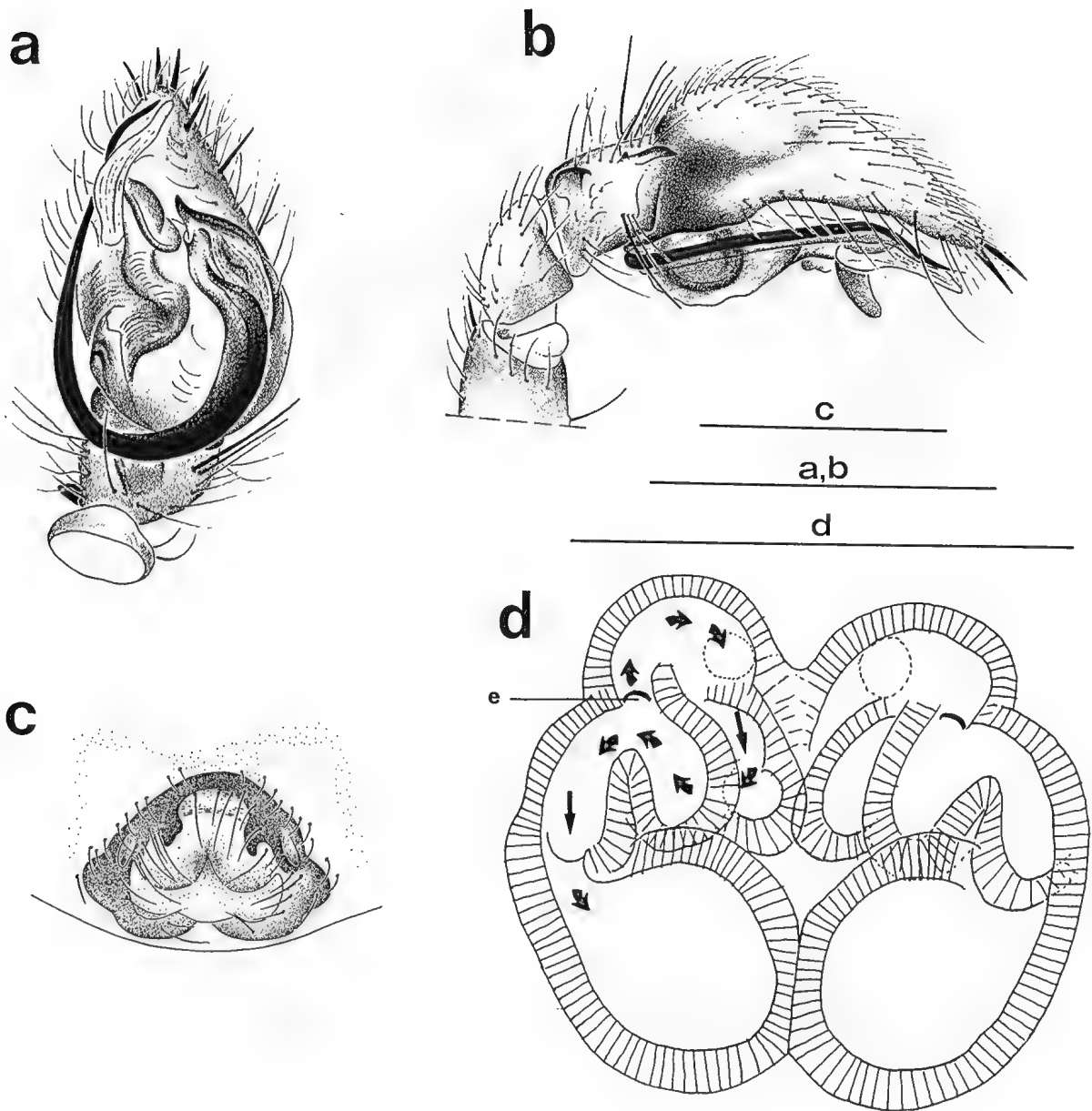


Fig. 17. *Zillimata scintillans* n.sp. a, male palp, ventral view, b, male palp, lateral view, c, epigyne, ventral view, d, epigyne, cleared, dorsal view, e, entrance opening, arrows indicate course of entrance ducts. Scales 1 mm.

*Habronestes* Koch

*Habronestes calamitosus* n.sp.

Fig. 18a-d

**Type material.** HOLOTYPE ♀: Australia, Queensland, 26 miles south-west of Sarina, 220 m, 19 November 1962, E.S. Ross & D.Q. Cavagnaro (CAS).

**Diagnosis.** This species is very similar to *H. striatipes* Koch, the type species. Males of the present species

were initially mistaken for those of *H. striatipes* which had poorly been described prior to Jocqué (1991). The male is easily recognised by the dorsal tibial apophysis of the palp, with a row of lateral teeth near the dorsal tip whereas it is a single tooth and a ridge in *H. striatipes*; the female is also similar to the type species of the genus, the epigyne differs by the fact that the converging margins of the central depression are not widened in *H. calamitosus*. It should be mentioned that other, similar species exist in the region of north-east Queensland.



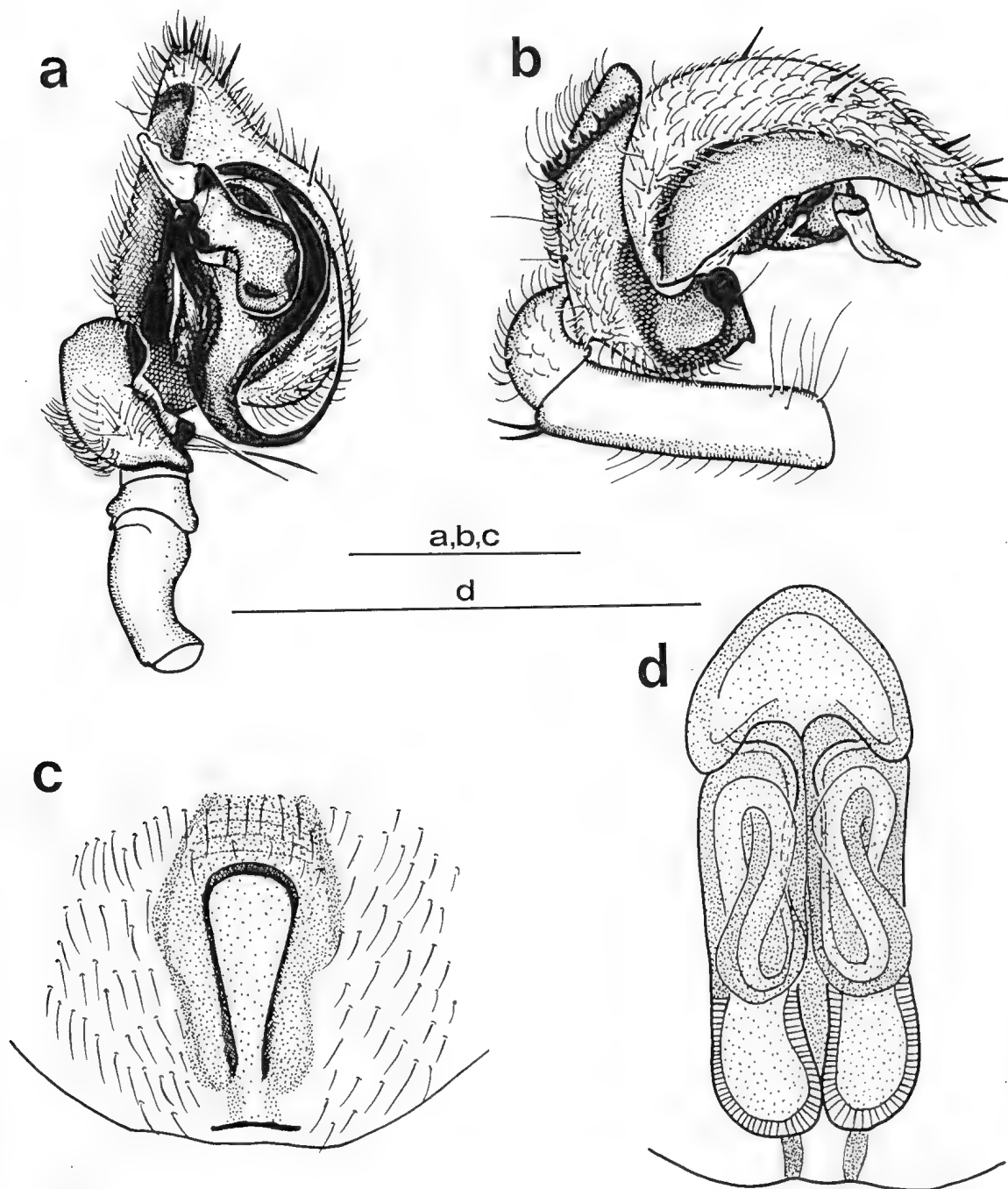


Fig. 18. *Habronestes calamitosus* n.sp. a, male palp, ventral view; b, male palp, lateral view; c, epigyne, ventral view; d, epigyne, cleared, dorsal view. Scales 0.5 mm.

**Etymology.** The name *calamitosus* means "disastrous" and refers to the fact that specimens had initially been misidentified as the type species of the genus.

#### Description

**Male.** Total length 5.79 mm; carapace 3.04 mm long, 2.25 mm wide.

**Colour:** carapace, chelicerae and sternum chestnut brown; coxae pale, trochanters dark. F I entirely chestnut brown; F II with pale dorsal patch in proximal part, F III with proximal pale ring, F IV with wider proximal pale ring. P I and II and T I and II yellow with brown lateral stripes, Mt and t of anterior pairs pale brown. T III and IV with paler dorsolateral stripe, Mt III and IV medium brown, t III and IV pale brown. Abdomen dark sepia; dorsum with central lyriform pattern, preceded

by two white spots followed by a few white spots on central line in front of spinnerets; sides with two oblique pale stripes; venter with median longitudinal stripe followed by two large pale spots in front of spinnerets.

Eyes: a, 0.09; b, 0.13; c, 0.10; d, 0.12; e, 0.05; f, 0.18; g, 0.26; h, 0.13; i, 0.13; AME-AME = 0.10. MOQ,  $AW = 1.48 \times PW$ ;  $AW = 0.69 \times L$ .

Leg measurements and spination are given in Tables 1 and 2.

Male palp (Fig. 18a,b): large, with high dorsal apophysis provided with row of teeth near dorsal margin.

**Female.** Total length 8.08 mm; carapace 3.41 mm long, 2.33 mm wide.

Colour as in the male but more white on femora; F I with ventral and dorsal dark brown stripe extending to half length of otherwise white femur; rings on F II, III and IV extending resp. to 1/4, 1/3 and half femur's length. Abdominal pattern more strongly contrasted.

Eye pattern as in male.

Leg spination as in male. Leg measurements given in Table 2.

Epigyne: see Fig. 18c,d.

**Other material examined.** QUEENSLAND: 4♂♂, 2♀♀, together with type (1♂, 1♀ in KBIN); 1♂, 3♀♀: Homevale, 1–7 April 1975, litter, V. Davies & R. Raven (QM S3683); 3♂♂, 2♀♀: MEQ, Homevale, 1–7 April 1975, riverine forest, (QM S3705).

**Distribution.** Coastal region of Queensland.

### *Asceua* Thorell

#### *Asceua expugnatrix* n.sp.

Fig. 19a–d

**Type material.** HOLOTYPE ♂: Australia, Northern Territory, Kemp Airstrip, 12°35'S, 131°20'E 15 November 1979, rain forest litter, R. Raven, (QM S 3831). PARATYPES: 1♀, with label data "as holotype" (QM S 3838); 1♀ and 1 juvenile: north Queensland, Iron Range, West Claudie River, 3–10 December 1985, rainforest, pyrethrum knock-down, G. Monteith & D. Cook (QM S 3797) (together with juvenile *Mallinella* sp.).

**Diagnosis.** Males of this species are recognised by the lateral tibial apophysis of the palp which is widened towards the strongly truncated tip; females have a semicircular lip near the anterior margin of the epigyne in which one sees diagonal ducts shining through.

**Etymology.** The name *expugnatrix* means "conqueror" and refers to the recent "invasion" of *Asceua* into the northern tip of the Australian continent (Jocqué, 1993).

### Description

**Male.** Total length 3.34 mm; carapace 1.48 mm long, 1.17 mm wide.

Colour: carapace, chelicerae and sternum pale brown; legs yellow with dark pro- and retrolateral stripes on Fe III and IV. Abdomen dark sepia with five dorsal white spots (Fig. 19a), paler on narrow dorsal scutum; sides with two oblique pale stripes enlarged to large white patch in anterior part of venter, narrowing towards spinnerets.

Eyes: a, 0.10; b, 0.10; c, 0.09; d, 0.10; e, 0.02; f, 0.02; g, 0.08; h, 0.09. MOQ,  $AW = 0.81 \times PW$ ;  $AW = 0.72 \times L$ .

Chilum an equilateral triangle.

Leg measurements given in Table 2. Spination: all femora with one dorsal spine; all metatarsi with a distal whorl of six small spines.

Male palp (Fig. 19b,c). Tibia with large lateral apophysis, widened towards tip which is indented; ventral prong distally with poorly defined knob; cymbium with typical huge lateral fold; distal end with recurved lip, proximal end near inferior margin with distinct ridge; tegulum with large terminal membranous appendage, widening towards extremity; two short lateral prongs at base of latter.

**Female** (values for Iron Range female in brackets). Total length 3.71 (2.66) mm; carapace 1.44 (1.26) mm long, 0.97 (0.95) mm wide.

Colour as in the male but more white on anterior femora also with dark stripes; no scutum on abdomen.

Eyes: a, 0.11; b, 0.10; c, 0.10; d, 0.10; e, 0.02; f, 0.02; g, 0.05; h, 0.10; MOQ,  $AW = 0.92 \times PW$ ;  $AW = 0.82 \times L$ .

Leg spination as in male. Leg measurements given in Table 2.

Epigyne (Fig. 19d). Anterior margin with semicircular lip. Copulatory ducts visible through integument, with marked diagonal part.

**Other material examined.** None.

**Distribution.** Northern coastal regions of Queensland and the Northern Territory.

### Discussion

Some of the conclusions presented in this paper may have important phylogenetic and biogeographical consequences. One of them is the inclusion of *Australutica* in the Lachesaninae. This is based on two apomorphies: the presence of well-developed pairs of spines on the anterior metatarsi but mainly the presence of elongate, retractable, cylindric AS, a character it shares with the three other genera of the subfamily viz. *Lachesana*, *Lutica* and *Antillorena*. Besides that, *Australutica* has a number of plesiomorphies which are absent in all other

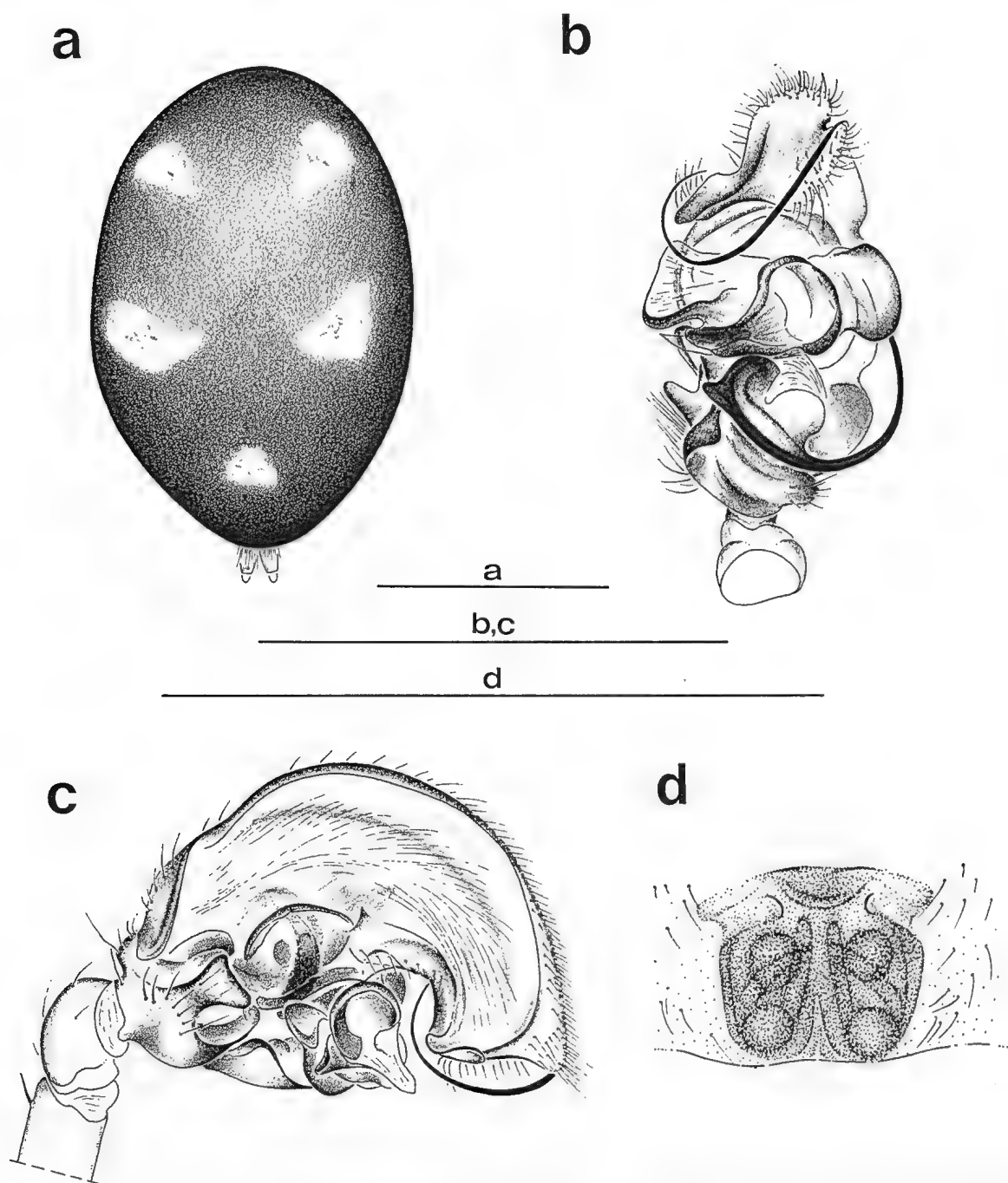


Fig. 19. *Asceua expugnatrix* n.sp. a, abdomen, dorsal view; b, male palp, ventral view; c, male palp, lateral view; d, epigyne, ventral view. Scales 1 mm.

Australian Zodariidae except *Nostera*. It is puzzling that *Australutica* indeed shares the simple palp conformation and the ovoid sternum with some of the species of *Nostera*. It could be argued that the palpal conformation found both in *Nostera*, as redefined by Jocqué (1995) and *Australutica*, is the plesiomorphic state although it is not clear at present what the plesiomorphic zodariid male palp should look like. The main reason is that the place of the Zodariidae in the Entelegynae is not yet clear (Coddington & Levi, 1991). This makes the

inclusion of *Australutica* in the Lachesaninae somewhat doubtful. Moreover, the validity of that heterogeneous subfamily can be questioned. The presence of the special AS on which the taxon is mainly based (Jocqué, 1991), is apparently an adaptation to life in dry sandy habitats and may have developed several times. But this could probably also be said of a large number of taxa recognised today. It is a fact that homoplasy is a very common event occurring with high frequency as is particularly clear from studies of large data-sets

(Coddington & Levi, 1991; Scharff & Coddington, pers. comm.). This makes one wonder whether one of the premises for the use of cladism is indeed fulfilled, more precisely that the quantity of homoplasy does not exceed the number of synapomorphies (Platnick, 1978). It would indeed seem that the number of morphological solutions for adaptive problems to which evolving creatures are faced is limited, and that similar answers evolve over and over again. It is not unlikely that, when in a group, the conditions are present to develop a morphological answer to a particular problem, that adaptation is easily acquired in several evolutionary lines.

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**Table 1.** Leg spination; *d*—dorsal, *disp*—dispersed, not in obvious rows, *dw*—distal whorl, *pl*—prolateral, *rl*—retrolateral, *v*—ventral.

	femur	patella	tibia	metatarsus
<i>Australutica moreton</i> n.sp.				
I	<i>pl1d3rl1</i>	—	<i>pl2rl1v2-2-2</i>	<i>pl1v11**</i>
II	<i>pl1d2rl2</i>	—	<i>pl3v2-2-2</i>	<i>pl1v19**</i>
III	<i>pl1d3*2</i>	<i>16disp</i>	<i>pl3d3rl2v8</i>	<i>9disp dw6</i>
IV	<i>pl1d1-2-1-2</i>	<i>16disp</i>	<i>pl3d3rl3v8</i>	<i>11disp dw6</i>
<i>Australutica manifesta</i> n.sp.				
I	<i>pl2*d1-1-2rl1</i>	—	<i>pl4*rl1v2-2-2</i>	<i>pl1-1v16**</i>
II	<i>pl2*d1-1-2rl2*</i>	<i>pl1</i>	<i>pl4*v2-1-2-2</i>	<i>pl2v11**</i>
III	<i>pl2*d1-1-2rl2*</i>	<i>pl15d4</i>	<i>pl4*d3*rl2-1-1v2-2-2</i>	<i>pl2rl2v8dw6</i>
IV	<i>pl2*d1-1-2rl2*</i>	<i>pl12d1</i>	<i>pl2-2-1d3*rl2-2-1-1v1-1-2-2</i>	<i>pl4rl2v8dw6</i>
<i>Australutica xystarches</i> n.sp.				
I	<i>pl1d3</i>	—	<i>v2-2-1</i>	<i>pl2v8**</i>
II	<i>pl1d2</i>	—	<i>pl2v2-2-2</i>	<i>pl1v6** dw5</i>
III	<i>pl2d2rl1</i>	<i>pl2d1rl1</i>	<i>pl42d3rl2v3-3-2</i>	<i>14disp dw6</i>
IV	<i>pl2d2rl1</i>	<i>pl2d1rl1</i>	<i>pl2d2rl2v2-4-2</i>	<i>10disp dw6</i>
<i>Australutica quaerens</i> n.sp.				
I	<i>pl1d2</i>	—	<i>v2-2-2</i>	<i>v2-2-3</i>
II	<i>pl1d2rl1</i>	—	<i>pl1v3*</i>	<i>pl1v2-2-3</i>
III	<i>pl1d1rl1</i>	<i>14disp</i>	<i>pl3*d2-1-1rl2*v2-1-2</i>	<i>10disp dw6</i>
IV	<i>pl1d2rl1</i>	<i>11disp</i>	<i>pl3d2rl2v2-2-2</i>	<i>13disp dw6</i>
<i>Australorena scenica</i> (Koch) n.comb. ♂				
I	<i>pl1d1</i>	—	—	<i>v2-2-2-3</i>
II	<i>pl1d1</i>	—	<i>v3*</i>	<i>v1-2-2</i>
III	<i>pl1d1</i>	<i>pl1rl1</i>	<i>pl2d2rl2v2-2-2</i>	<i>8disp dw6</i>
IV	<i>pl1d3</i>	<i>pl1rl1</i>	<i>pl3d2rl2v1-2-2</i>	<i>10disp dw6</i>
<i>Australorena scenica</i> (Koch) n.comb. ♀				
I	<i>pl1d1</i>	—	—	<i>v2-2-2-3</i>
II	<i>pl1d1</i>	—	<i>v2*</i>	<i>v2-2-3</i>
III	<i>pl2d3rl1</i>	<i>pl1d1rl1</i>	<i>pl2d2rl2v2-2-2</i>	<i>8disp dw6</i>
IV	<i>pl1d2</i>	<i>pl1d1rl1</i>	<i>pl3d2rl2v2-2-2</i>	<i>10disp dw6</i>
<i>Chilumena reprobens</i> n.sp.				
I	<i>d1-1v1</i>	—	<i>pl1v1-1</i>	<i>v2-1-2</i>
II	<i>d1-1v3*</i>	—	<i>v1-1-2</i>	<i>v2-2</i>
III	<i>d4*v3*</i>	<i>d1rl1</i>	<i>pl3d2rl2v2-1-2</i>	<i>8disp dw6</i>
IV	<i>d4*v1</i>	<i>pl1d1rl1</i>	<i>pl3d2rl3v2-1-2</i>	<i>10disp dw6</i>
<i>Chilumena baehrorum</i> n.sp.				
I	<i>pl1d1-1</i>	—	<i>d1v2-1</i>	<i>v1-2</i>
II	<i>d2v2</i>	—	<i>d1v1-1</i>	<i>v2-1-2 dw4</i>
III	<i>d2v1</i>	<i>pl1d1rl1</i>	<i>pl2d2rl3v2-2-2</i>	<i>8disp dw6</i>
IV	<i>d4v3</i>	<i>pl1d1rl1</i>	<i>pl3d2rl3v1-1</i>	<i>10disp dw6</i>
<i>Zillimata scintillans</i> (Pickard-Cambridge) n.comb. [Jerdacuttup ♀]				
I	<i>pl1d3*</i>	—	<i>pl1d1v1-1</i>	<i>v1-2</i>
II	<i>pl1d2*</i>	—	<i>pl2rl1v1-1-2</i>	<i>v2-1-2 dw4</i>
III	<i>d3*rl1</i>	<i>pl2d1rl2</i>	<i>pl2d2rl3v2-1-2</i>	<i>8disp dw6</i>
IV	<i>d3*rl1v3</i>	<i>pl1d2rl2</i>	<i>pl3d3rl3v2-1-2</i>	<i>10disp dw6</i>
<i>Zillimata scintillans</i> (Pickard-Cambridge) n.comb. ♂				
I	<i>pl1d2*</i>	—	<i>v1</i>	—
II	<i>d3*rl1</i>	—	<i>pl2v1-1-2</i>	<i>v1-1-1 dw3</i>
III	<i>pl1d3*rl1</i>	<i>d1rl1</i>	<i>pl3d3rl2v2-1-2</i>	<i>10disp dw6</i>
IV	<i>d3*rl1</i>	<i>pl1d1rl1</i>	<i>pl2d3rl2v2-1-2</i>	<i>12disp dw6</i>
<i>Habronestes calamitosus</i> n.sp. ♂				
I	<i>pl1d3*</i>	—	<i>v2-2-2</i>	<i>v16</i>
II	<i>pl1d3*</i>	—	<i>pl1v2-2-2</i>	<i>pl1v1-2-2-2</i>
III	<i>pl1-1d3*rl1</i>	<i>pl1d-1rl1</i>	<i>pl3*d4*rl2*v2-2-2</i>	<i>12disp dw6</i>
IV	<i>pl1-1d3*rl1</i>	<i>pl1d1-1rl1</i>	<i>pl3*d4*rl2*v2-2-2</i>	<i>12disp dw6</i>

**Table 2.** Leg measurements. F—femur; P—patella; T—tibia; Mt—metatarsus; t—tarsus; Tot—total.

	F	P	T	Mt	t	Tot
<i>Australutica moreton</i> n.sp.						
I	2.85	1.06	2.25	2.30	1.49	9.95
II	2.76	1.06	2.04	2.39	1.41	9.66
III	2.43	1.06	1.58	2.77	1.53	9.37
IV	3.06	0.98	2.34	3.88	1.75	12.01
<i>Australutica manifesta</i> n.sp.						
I	3.83	1.32	2.72	2.85	1.75	12.47
II	3.58	1.32	2.26	2.81	1.83	11.80
III	3.19	1.28	1.83	3.32	1.87	11.49
IV	3.83	1.41	2.56	4.38	2.39	26.06
<i>Australutica xystarches</i> n.sp.						
I	3.66	1.62	3.07	2.77	1.62	12.44
II	3.62	1.62	2.55	2.85	1.58	12.22
III	3.32	1.49	1.87	2.64	1.49	10.81
IV	3.92	1.79	2.81	4.05	1.83	14.40
<i>Australutica quaerens</i> n.sp.						
I	1.79	0.70	1.34	1.38	0.82	6.03
II	1.75	0.70	1.17	1.23	0.80	5.65
III	1.63	0.68	0.99	1.73	1.03	6.06
IV	2.00	0.72	1.50	2.10	1.13	7.45
<i>Australorena scenica</i> (Koch) n.comb. ♂						
I	2.14	0.93	1.63	1.72	1.58	8.00
II	1.81	0.74	1.39	1.58	1.11	6.65
III	1.72	0.84	1.07	1.67	0.93	6.23
IV	2.46	0.93	1.49	2.70	1.35	8.93
<i>Australorena scenica</i> (Koch) n.comb. ♀						
I	2.23	1.07	1.67	1.53	1.25	7.76
II	1.86	0.88	1.39	1.39	1.17	6.69
III	1.63	0.74	1.11	1.63	1.16	6.28
IV	2.32	0.98	1.77	2.56	1.39	9.02
<i>Chilumena reprobans</i> n.sp.						
I	2.00	0.55	2.13	1.92	1.53	8.13
II	1.57	0.55	1.36	1.53	0.94	5.93
III	1.41	0.68	1.15	1.49	0.68	5.41
IV	1.87	0.72	1.62	2.13	0.85	7.19
<i>Chilumena baehrorum</i> n.sp.						
I	1.92	0.77	1.70	1.75	1.40	7.54
II	1.53	0.68	1.15	1.36	0.77	5.49
III	1.40	0.77	1.02	1.32	0.77	5.28
IV	1.83	0.72	1.49	1.96	0.81	6.81
<i>Zillimata scintillans</i> (Pickard-Cambridge) n.comb. [Jerdacuttup ♀]						
I	1.58	0.64	1.53	1.45	1.23	6.43
II	1.40	0.64	1.10	1.23	0.89	5.26
III	1.32	0.68	0.98	1.40	0.85	5.23
IV	1.79	0.68	1.32	1.83	1.10	6.72
<i>Zillimata scintillans</i> (Pickard-Cambridge) n.comb. ♂						
I	1.62	0.55	1.36	1.32	1.15	6.00
II	1.45	0.55	0.89	1.15	0.81	4.85
III	1.11	0.55	0.77	1.19	0.72	4.84
IV	1.45	0.64	1.19	1.70	0.89	5.87

Continued...

Table 2. Continued.

	F	P	T	Mt	t	Tot
<i>Habronestes calamitosus</i> n.sp. ♂						
I	2.67	0.91	2.46	2.33	1.75	10.13
II	2.33	0.91	1.83	2.00	1.37	8.46
III	2.21	0.91	1.71	2.42	1.17	8.42
IV	2.83	1.04	2.46	3.83	1.42	11.59
<i>Habronestes calamitosus</i> n.sp. ♀						
I	2.33	0.95	1.79	1.96	1.46	8.51
II	2.08	0.87	1.46	1.63	1.25	7.29
III	1.88	0.96	1.41	2.08	1.08	7.42
IV	2.50	1.08	2.00	3.04	1.37	10.01
<i>Asceua expugnatrix</i> n.sp. ♂						
I	0.99	0.41	0.88	0.86	0.62	3.76
II	0.86	0.35	0.74	0.74	0.51	3.20
III	0.84	0.37	0.68	0.80	0.41	3.10
IV	1.05	0.37	0.88	1.03	0.51	3.84
<i>Asceua expugnatrix</i> n.sp. ♀						
I	0.89	0.33	0.72	0.74	0.62	3.30
II	0.82	0.33	0.62	0.20	0.51	3.00
III	0.82	0.35	0.60	0.76	0.43	2.96
IV	0.95	0.35	0.84	0.95	0.54	3.63



## Notes on Australian Zodariidae (Araneae), II. Redescriptions and New Records

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**ABSTRACT.** The species of Australian Zodariidae that were described prior to Jocqué (1991) are listed and those of which the identity could be traced are redescribed. *Neostorena vituperata* and *Nostera nadgee* (♂, ♀) are described as new and *Nostera* is widened to accommodate *Nostera leucosema* (Rainbow) n. comb. Other new combinations are *Habronestes grimwadei* (Dunn), *Habronestes macedonensis* (Hogg), *Habronestes toddi* (Hickman), *Storosa tetrica* (Simon), *Neostorena torosa* (Simon), *Neostorena spirafera* (Koch) and *Mallinella zebra* (Thorell). The species *Hetaerica aresca* and *H. variegata* and the genus *Hetaerica* are invalidated. New records for a number of recently described species are provided.

JOCQUÉ, RUDY, 1995. Notes on Australian Zodariidae (Araneae), II. Redescriptions and new records. Records of the Australian Museum 47(2): 141–160.

In this second of two papers clarifying the confused taxonomy of Australian Zodariidae, all known Australian species that were not treated in Jocqué (1991), Jocqué & Baehr (1992) or Jocqué (1995) are redescribed. New distributional data on these species and some of the recently described species are added. Some species mentioned in the catalogue of Davies (1985) (see Table 1) are considered “species inquirendae” either because the combination of an insufficient initial description and loss of types, or the description of juveniles, makes it impossible to diagnose the taxon. A key to the genera is provided in Jocqué (1995).

### Methods

The methods and format are similar to those used by Jocqué & Baehr (1992). All measurements are in millimetres.

**Abbreviations** are given in Jocqué (1995, p. 118, this issue). Museums and other institutions are abbreviated as follows: AM—Australian Museum, Sydney (M. Gray); AMNH—American Museum of Natural History, New York (N. Platnick); BMNH—Natural History Museum, London (P. Hillyard); CAS—California Academy of Sciences (W. Pulawski & D. Ubick); KBIN—Koninklijk Belgisch Instituut voor Natuurwetenschappen, Brussels (L. Baert); MCSNG—Museo Civico di Storia naturale, Genoa (G. Doria); MCZ—Museum of Comparative Zoology, Cambridge (H. Levi); MNHN—Musée national d'Histoire naturelle, Paris (J. Heurtault & C. Rollard); NVM—Victoria Museum, Melbourne (M. Harvey); NRS—Naturhistoriska Riksmusset, Stockholm (T. Kronestedt); QM—Queensland Museum, Brisbane (R. Raven); RMNH—Rijksmuseum van Natuurlijke Historie, Leiden (P. Van Helsdingen); SAMA—South Australian Museum Adelaide (D. Hirst); UMO—University Museum,

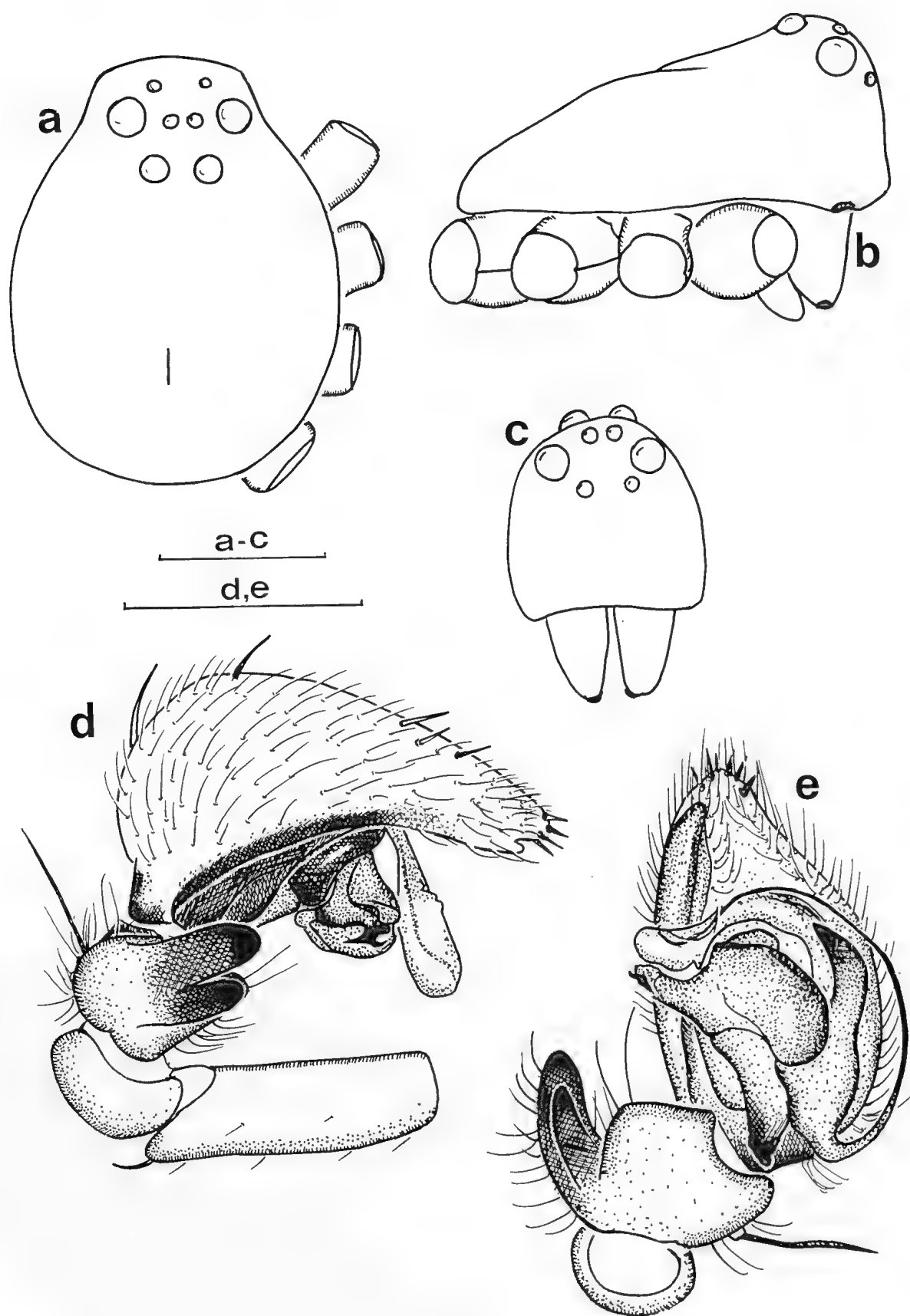


Fig. 1. *Habronestes australiensis* (Pickard-Cambridge) a, carapace, dorsal view; b, carapace, lateral view; c, carapace, frontal view; d, male palp, lateral view; e, male palp, ventral view. Scales 1 mm.

Hope Entomology Collections, Oxford (J. Lansbury); WAM—Western Australian Museum, Perth (M. Harvey); ZMB—Zoologisches Museum, Berlin (M. Moritz); ZMH—Zoologisches Museum, Hamburg (G. Rack).

### Taxonomy

#### *Habronestes* Koch

##### *Habronestes australiensis* (Pickard-Cambridge)

Fig. 1a–e

*Storena australiensis* Pickard-Cambridge, 1869: 58 (description of ♂).—Rainbow, 1911: 149.

*Habronestes australiensis* [sic].—Koch, 1872: 302, 307 (description of ♂).

**Remarks.** The type specimen has been dried and pinned at one stage. All legs are detached and it is therefore impossible to check the unusual formula of leg lengths (4231) as given by Pickard-Cambridge (1869). Koch (1872: 307) mentions: "Ich habe diese ausgezeichnete Spinne nach vielem Bedenken zu dem Genus *Storena* Walck. gerechnet". In the same paper, however, he introduces the new combination *H. australiensis* (*australensis* [sic] is an obvious lapsus) which now appears to be correct. The male palp has the typical conformation, diagnostic of the genus that is the Y-shaped tegulum.

**Type material.** Holotype ♂: Australia (UMO 126, examined).

**Diagnosis.** The male of this species is recognised by the two lateral tibial apophyses of the palp, both broadly rounded at the tip; the large membranous tegular apophysis is equally characteristic.

### Description

**Male.** Total length 5.00 mm; carapace 2.54 mm long, 1.96 mm wide.

Colour: chitinated parts virtually uniform medium brown except femora of anterior leg pairs which are orange in the proximal half.

Eyes: Fig. 1a–c. Clypeus 0.63 mm high.

Leg formula as given by Pickard-Cambridge (1869) probably wrong. Some of the legs with numerous long spines. Hinged hairs present. Six spinnerets.

Male palp (Fig. 1d,e): tibia with two lateral apophyses, the inferior one shorter and narrower than the superior one; both rounded at extremity. Cymbial fold short; curved sclerotised part of tegular "Y" short and pointed at extremity; tegular apophysis membranous, large, widened toward extremity and pointing downward.

**Female.** Unknown.

**Distribution.** Imprecise; the holotype, the only known specimen, is from "Australia".

##### *Habronestes bradleyi* (Pickard-Cambridge)

Fig. 2a,b

*Storena bradleyi* Pickard-Cambridge, 1869: 55, table IV, figs 12–20 (description of ♂).

*Habronestes bradleyi*.—Koch, 1872: 305 (description of ♂).

*Storena ?bradleyi*.—Kritscher, 1956: 246 (description of ♀).

**Type material.** LECTOTYPE ♂ (by present designation): Australia, New South Wales, Sydney, Bradley (UMO) (examined). PARALECTOTYPES: 1♂, 1 juvenile (together with lectotype).

**Other material examined.** One ♂, Victoria, Tallarook, 25 September 1977, on ground, H. Parnaby (AM KS20238).

**Diagnosis.** The male of *H. bradleyi* is easily recognised by the presence of numerous spatulate hairs on the ventral side of Mt I. Both sexes are recognised by the small eyes of the anterior row as compared to those of the second row.

### Description

**Male.** Total length 4.80 mm; carapace 2.42 mm long, 1.92 mm wide.

Colour. The specimens of the type series are apparently strongly bleached; carapace uniform pale brown; chelicerae and sternum brownish yellow, legs brown to yellow, darkened towards the femora; trochanters pale yellow; abdomen dark grey with white dots on dorsum; a long oval pale patch on either side.

Eyes in anterior row small as compared to those of second row; AME less than their radius apart and with a diameter of 0.07 mm; ALE 3 times their diameter apart and slightly smaller (0.06 mm) than AME; PME twice as large as ALE and about their diameter apart; PLE twice as large as AME and 2.5 times their diameter apart. MOQ, AW = 0.5×PW; AW = 0.5×L. Clypeus straight; 0.62 mm high or about 10 times the diameter of an ALE.

Legs: measurements and spination are given in Tables 2 and 3.

Male palp, see Fig. 2a,b.

**Female.** See Kritscher's (1956) description.

**Distribution.** South-eastern Australian mainland.

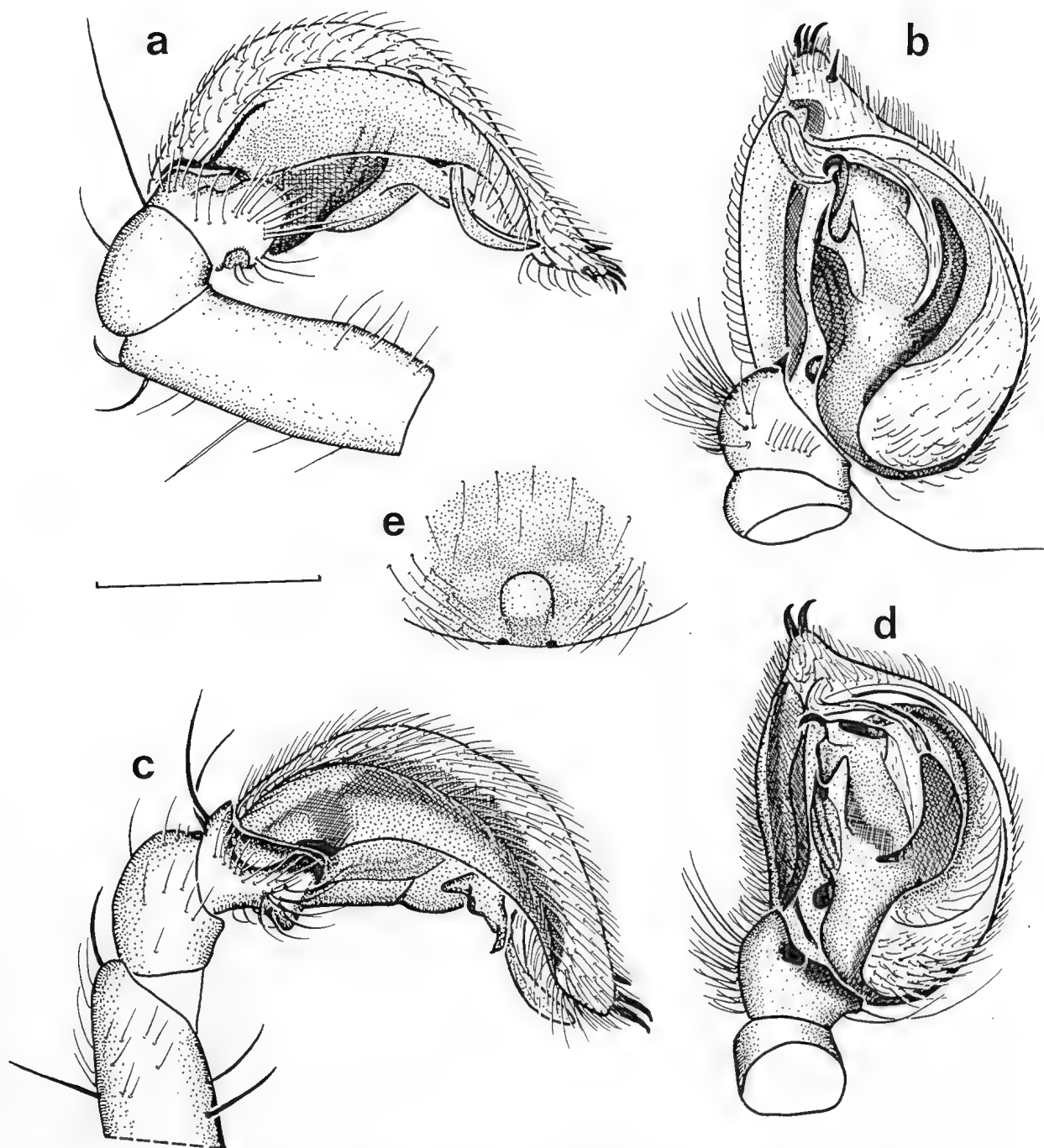


Fig. 2. *Habronestes bradleyi* (Pickard-Cambridge) a, male palp, lateral view; b, ventral view. *Habronestes grimwadei* (Dunn) c, male palp, lateral view; d, male palp, ventral view; e, epigyne. Scale 1 mm.

*Habronestes grimwadei* (Dunn) n.comb.

Fig. 2c–e

*Storena grimwadei* Dunn, 1951: 11, figs 1–4 (descriptions of ♂ and ♀).

**Type material.** HOLOTYPE ♂: Australia, Western Australia, about 40 miles west of Eucla, 31°43'S, 128°53'E, 30 August

1947, preying on *Iridomyrmex* sp., R. Pescott (NVM) (examined). PARATYPES: 2♀♀, together with holotype (examined).

**Other material examined.** QUEENSLAND: 5♂♂, 3♀♀, Mulgowie, Lardly Valley, 21 January 1981, *Eucalyptus* woodland, M. Grant (QM S3719); 1♂, 1♀: same data as previous (KBIN); 2♂♂, Mulgowie, September–November 1981, M. Grant (QM S3720); 2♂♂, same data as previous,

5 May 1981 (QM S3718); Windermere Station, Brigalow, 27°25'S, 149°41'E, 5 December 1987, R. Raven (QM S2480); 1♂, SCQ, Ambathala, 9 May 1979, K.M. Donald (QM S4460). VICTORIA: 1♀, 8.3 km east of confluence of Lindsay River and Mullaroo Creek, 34°11'S 141°10'E, site 103, pitfall, November 1985, A. Yen (NVM); 2♂♂, 6.7 km SSW of junction MV highway and Annuello Road, 34°51'S 42°36'E, pitfall, January 1986, A. Yen (NVM); 1♂, same data as previous but October 1985; 1♀, Bacchus Marsh, 10 October 1974, V. Salinitri (NVM); SOUTH AUSTRALIA: 1♂, Munyaroo Conservation Park, 8 km SW Moonabie Homestead, 33°19'S 137°12'30"E, 28 April 1991, pitfall, Head & Jansen (SAMA N199279); WESTERN AUSTRALIA: 1♂, Tenterden, 7 February 1969, H. Osburne (AM KS15636); 1♀, near Weebubbe Cave, 30 December 1971, cave, M. Gray (AM KS15619). NEW SOUTH WALES: 2♂♂, Mount Lambie, 13 November 1988, G.S. Hunt (AM KS29940); 1♂, Bungonia Caves area, near information centre, November 1989, G. Hunt (AM KS22566); 1♂, Armidale, running on rock "Warrana", September 1978, K. Jacques (QM S3849); 1♂, Kowar Forest, ACT, 12 September 1985 (QM S4383).

**Diagnosis.** The species has a characteristic colour pattern: a bright orange carapace with contrasting dark sepia abdomen with white dots. The male is recognised by the palpal tibia with deep lateral concavity whereas the female has a typical epigyne with central concavity. The species is also remarkable by having leg II slightly longer than leg I. The species is closely related to *H. bradleyi* with which it shares the modified hairs on the anterior Mt.

### Description

**Male.** Total length 4.17 mm; carapace 2.29 mm long, 1.75 mm wide.

Colour. Carapace bright orange with a large darker V in front of fovea and faint radiating striae; in eye region with bluish metallic lustre; chelicerae and legs, yellowish orange, metatarsi and tarsi paler; sternum brownish orange. Abdomen dark sepia in front with a white collar interrupted in the middle; a white spot on each side just behind the middle and two small ones just in front of the spinnerets. Remainder dark sepia.

Carapace profile evenly rounded, reaching highest point halfway between fovea and eyes.

Eyes: both rows strongly procurved thus giving the impression of four levels; a, 0.07; b, 0.06; c, 0.08; d, 0.11; e, 0.05; f, 0.06; g, 0.15; h, 0.13. MOQ, AW = 0.63×PW; AW = 0.53×L.

Legs: measurements and spination are given in Tables 2 and 3. Anterior legs with short modified ventral setae on metatarsi and distal half of tibiae.

Male palp (Fig. 2c,d): tibia with double lateral keel, delimiting a rather wide lateral concavity; bulbus typical for genus with hook-shaped tegular apophysis and long and narrow subtegular membrane.

**Female.** Total length 5.42 mm; carapace 2.83 mm long, 2.04 mm wide.

Colour as in male.

Eyes as in male.

Relative length and spination of legs as in male but Mt I and T I without modified ventral setae.

Epigyne (Fig. 2e): with roughly quadrangular central concavity. The appearance of the epigyne varies greatly with the angle at which it is viewed.

**Variation.** There is considerable variability in the number and position of the white spots on the abdomen. In front of the pair of white dorsal spots there may be second pair of smaller white spots, whereas in some specimens the white spots are reduced to tiny points.

**Distribution.** Western Australia, Victoria, New South Wales and Queensland.

### *Habronestes macedonensis* (Hogg) n.comb.

Fig. 3c,d

*Storena macedonensis* Hogg, 1900: 2, 97, 98.—Rainbow, 1911: 150.

**Type material.** HOLOTYPE ♂: Australia, Victoria, Macedon (BMNH 1907.2.24.38) (examined).

**Diagnosis.** The male of this species is recognised by the two short, pointed tibial apophyses; the lateral one provided with a short rounded dorsal lamella; the ventral one short and pointed. The presence of a distal whorl of six short spines on F III and F IV is also characteristic.

### Description

**Male.** Total length 5.67 mm; carapace 2.98 mm long, 2.21 mm wide.

Colour. Carapace medium brown with some darker markings radiating from fovea; legs medium brown with white rings (precise pattern not clear as all legs are detached at least from patella onwards). Dorsum of abdomen sepia with two rows of white spots in front, followed by a median triangle and a longitudinal spot in front of spinnerets; sides almost entirely white; venter pale brown, darker in front of spinnerets.

Eyes: a, 0.21; b, 0.13; c, 0.15; d, 0.15; e, 0.05; f, 0.06; g, 0.11; h, 0.18. MOQ, AW = 1.14×W; AW = 0.94×L. Clypeus straight: 0.56 mm high or about 4.3 times width of ALE.

Legs: measurements of femora I 2.60; II 2.47; III 2.34; IV 2.81. Spination of femur: I *pl1d3\**; II *pl1d3\*rl1*; III *pl2\*d3\*rl3\*dw6*; IV *pl1d3\*dw6*.

Male palp (Fig. 3c,d): tibia with two apophyses: a short, pointed lateral one provided with a short rounded dorsal lamella and a pointed ventral one.

**Female.** Unknown.

**Distribution.** Known only from the type locality, Macedon, Victoria.

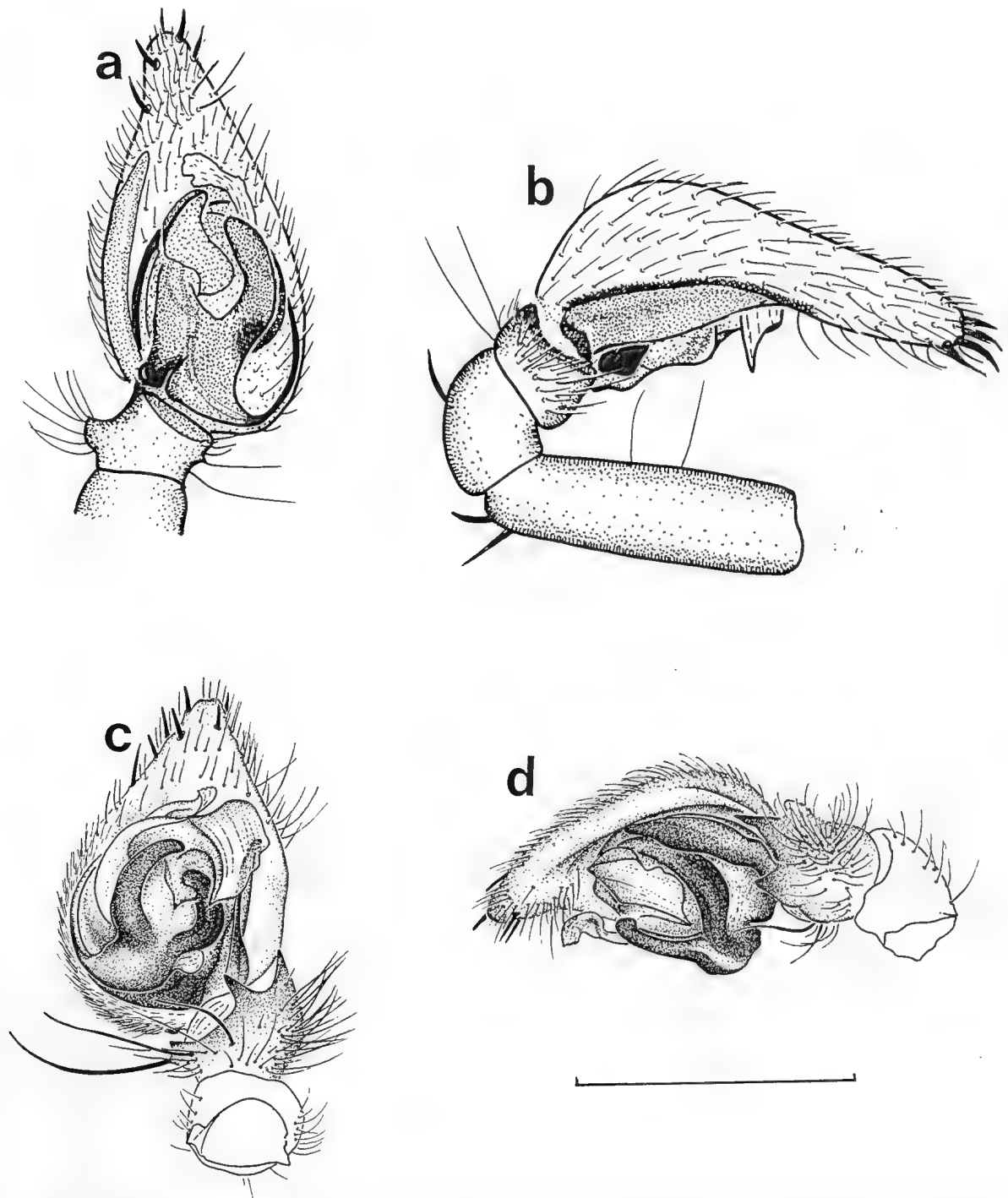


Fig. 3. *Habronestes toddi* (Hickman) a, male palp, ventral view; b, male palp, lateral view. *Habronestes macedonensis* (Hogg) c, male palp, ventral view; d, male palp, lateral view. Scale 1 mm.

*Habronestes toddi* (Hickman) n.comb.

Fig. 3a,b

*Storena toddi* Hickman, 1944: 38 (description of ♂).

**Type material.** HOLOTYPE ♂: Australia, Northern Territory, c. 24°S 136°E, 6 miles north of junction of Todd and Hale

Rivers, Simpson Desert Expedition, coll. 540 (AM KS6686) (examined). The type specimen is in bad condition, the carapace and abdomen are shrunk, apparently due to drying.

**Diagnosis.** The male of this species is easily recognised by the denticles on the ventral side of T I and Mt I, by the absence of a well defined tibial apophysis on the palp and by the elongate cymbium.

### Description

**Male.** Total length 3.33 mm; carapace 1.96 mm long, width not measured.

Colour. Carapace pale yellow in thoracic area, yellowish brown on cephalic area; chelicerae as cephalic area; sternum and legs pale yellow. Abdomen grey with white spots: two rather large ones and finally a fourth pair of small one; a large single patch in front of spinnerets. Sides with a longitudinal white patch; venter pale grey.

Eyes: a, 0.17; b, 0.11; c, 0.09; d, 0.12; e, 0.05; f, 0.04; g, 0.15; h, 0.15. MOQ,  $AW = 1.17 \times W$ ;  $AW = 0.95 \times L$ . Clypeus straight: 0.53 mm high or 4.82 times width of ALE.

Legs: measurements and spination are given in Tables 2 and 3. T I and proximal half of Mt I with numerous short ventral denticles.

Male palp (Fig. 3a,b): tibia with a lateral ridge bearing some setae but without a well pronounced apophysis; cymbium elongate; tegulum typically Y-shaped.

**Female.** Unknown.

**Distribution.** Known only from the type locality in central Australia.

### *Habronestes striatipes* Koch

*Habronestes striatipes* Koch, 1872: 313, pl XXV, fig. 4 (description of ♀).—Butler, 1876: 353.

*Storosa striatipes*.—Simon, 1893: 427.—Hogg, 1900: 72.—Rainbow, 1911: 151.—Rainbow, 1912: 191.—Jocqué, 1991: 57 (descriptions of ♂ and ♀).

**Material examined.** QUEENSLAND: 1♂, 7♀♀, Rundle Range, 24–31 March 1975, RK VED (QM 3684).

**Distribution.** Coastal areas of Queensland.

### *Storosa* Jocqué

#### *Storosa tetrica* (Simon) n.comb.

Fig. 4a–e

*Storosa tetrica* Simon, 1908: 403 (description of ♀).

**Type material.** HOLOTYPE ♀, Australia, Albany (Hamburg S.W. Austral. Exped. 1905, 13–22.VIII) (ZMB 24535) (examined).

**Other material examined.** WESTERN AUSTRALIA: 1♂, 5♀♀, Augusta, 7 March 1927, W.S. Brooks (MCZ); 2♀♀, Pemberton, 17–20 March 1927, further as previous; 1♂, 2♀♀, Manjinup, January–February 1927, further as previous; 3♀♀, 25 miles NW Walpole, 100 m, 26 September 1962, Ross & Cavagnaro (CAS); 1♂, Bedfordale, 2 April 1989, T. & R. Bickley (WAM); 1♀, Bedfordale, P. Hearne, 3 March 1988 (WAM);

Nornalup near Walpole National Park, 18 July 1982, A. Douglas (WAM); 2♂♂, Wilson Inlet, site 2, 34°59'S 117°22'E, 1 February 1986, G. Harold (WAM); 2♂♂, 1♀, 1 juvenile, William Bay National Park, February–March 1988, R. MacMillan (WAM); 1♀, Stirling Ranges, 15 May 1975, S. Slack-Smith (WAM); 1♀, Peg Brookton Road, 30 m, April 1963, A. Jones (WAM); 1♀, Augusta, c. 4 km E Ellis property, 25 October 1980, S. Slack-Smith (WAM); 1♂, 1♀, Withcliffe, 11 April 1939, H. Glauert (WAM); 1♀, William Bay National Park, 10 April 1982, McCrum (WAM); 1♂, 2♀♀, 12 km W of Manjinup, 11 March 1971, H. Butler (WAM); 1♂, 1♀, Dombalup State Forest, Marri Road, 34°30'S 116°00'E, 15 January 1979, pitfall, M. Gray (AM KS15265); 1♂, Burnside, Margaret River area, 33°56'S 115°01'E, pitfall, 17 February 1979, M. Gray (AM KS15132); 1♂, Boranup Drive Caves Road, 34°05'S 115°03'E, 17 February 1979, pitfall, M. Gray (AM KS15158).

**Diagnosis.** The species is easily recognised by the large white dorsal patch in front of the spinnerets; the female is recognised by the simple epigyne with central oval depression, well delimited in front and on the sides and by the spermathecae without frontal extension, hardly touching in front. The male is recognised by the shape of the palpal tibia in which the dorsal concavity is delimited by two apophyses, it is further characterised by the posterior swollen extension of the tegulum and by the bifid frontal tegular membrane.

### Description

**Female.** Total length 9.16 mm; carapace 4.62 mm long, 2.96 mm wide.

Colour. Carapace, chelicerae and sternum reddish brown; legs orange; abdomen dark grey with rectangular or oval white dorsal patch in front of spinnerets (Fig. 4a). Venter sometimes with broad median white band. Carapace: smooth in cephalic area, slightly granulated in thoracic area. Fovea short, not deep.

Eyes in two strongly recurved rows; a, 0.17; b, 0.16; c, 0.12; d, 0.16; e, 0.08; f, 0.12; g, 0.14; h, 0.30. MOQ,  $AW = PW$ ;  $AW = 0.90 \times L$ . Clypeus 0.44 mm high or 2.75 times width ALE; slightly retreating. Chilum double but separation of sclerites not complete; each half 0.70 mm wide and 0.30 mm high. There are two tiny sclerites underneath the larger ones. Chelicerae 1.78 mm long. Swollen, with large long condyle; almost bare except for distomesal group of setae in front of fangs. Sternum almost as wide (1.66 mm) as long (1.87 mm).

Legs: measurements and spination are given in Tables 2 and 3.

Palpus: claw with teeth; tarsus distally with long spines.

Epigyne (Fig. 4d,e) with central depression poorly delimited in the back well delimited in front, with two tiny openings in the middle. Entrance ducts complex; spermathecae near posterior margin, hardly touching in front; without frontal extension.

**Male.** Total length 9.25 mm; carapace 4.83 mm long, 2.92 mm wide; ocular area 1.08 mm wide.



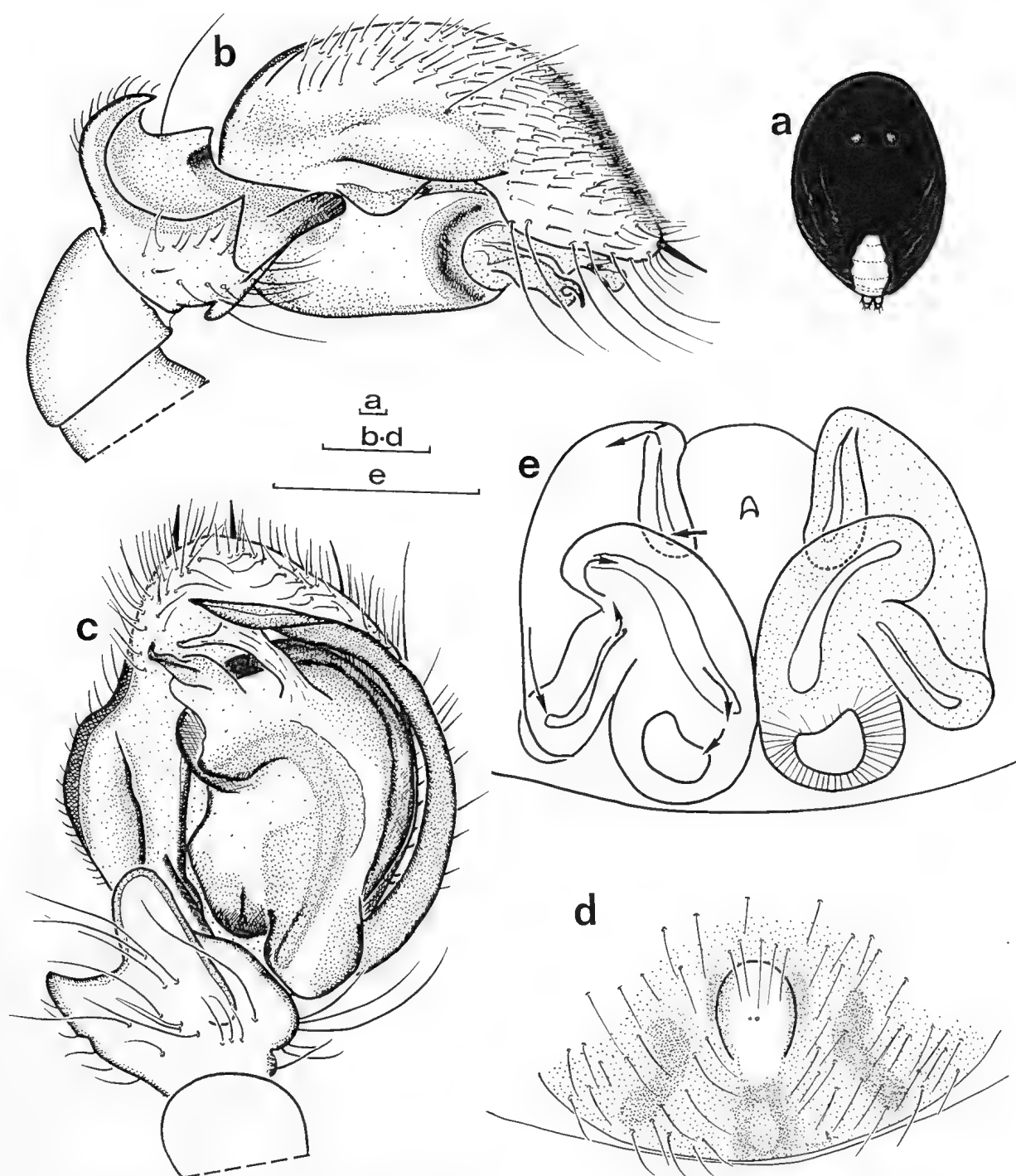


Fig. 4. *Storsia tetrica* (Simon) a, abdomen, ventral view; b, male palp, lateral view; c, male carapace, ventral view; d, epigyne, ventral view; e, epigyne, cleared, dorsal view. Arrows show course of entrance ducts. Scales 0.5 mm.

Colour as female except for narrow brown scutum in frontal half of abdomen and sclerotised area in front of epigastric fold. Carapace slightly reticulate in cephalic area, more strongly so in thoracic area.

Eyes as in female. Sternal boss poorly developed.

Palp: Fig. 4b,c. Dorsal concavity of tibia posteriorly delimited by two apophyses, a dorsal one and a lateral

one, and anteriorly produced into a short, rounded ventrolateral apophysis. Embolus massive, folded in distal part; tegular membrane slender; tegular apophysis with narrow distal part.

**Distribution.** South-western Western Australia.

*Storosa obscura* Jocqué

*Storosa obscura* Jocqué, 1991: 91.

**Material examined.** QUEENSLAND: 2♂♂, SE Qld, Flinton Hill, via Ipswich, 120 m, 1975–1976, G. & S. Monteith (QM S12170); 4♂♂, as previous (QM S12147); 1♀, SE Qld, Upper Yarraman State Forest, via Maidenwell, 610 m, 1974–1975, G. & S. Monteith (QM S12172); 1♂, as previous (QM S12119); 1♀, Sarabah National Park, via Canungra, 120 m, 1976–1977, G. & S. Monteith (QM S12178); 1♂, SE Qld, Mount Nebo, 4 March 1988, P. Stevenson (QM S12244); 1♀ with cocoon, SE Qld, Mount Nebo, 29 October 1978, rainforest, in hole in ground, A. Rozefelds (QM S4417); 1♂, SE Qld, Mount Tenison Woods, via Mount Glorious, 762 m, 1975–1976, G. & S. Monteith (QM S12177); 1♂, 1♀, as previous (QM S12146); 1♂, 1♀, as previous (QM S12216); 2♂♂, Burnett Range, 15 km NE of Tansey, 400 m, 13 December–26 March 1977, rainforest pitfall, G. & S. Monteith (QM S12179); 1♂, as previous, 26 March–5 September 1977 (QM S12186); 1♂, as previous, 26 March–5 September 1977 (QM S12212); 1♂, SE Qld, Kroombit Tops, 23–25 February 1982, pitfall in open forest with *Casuarina*, G.B.M., R.J.R., & G. Thompson (QM S12160); 1♀, Kroombit Tops, 45 km SSW Calliope, 9–19 December 1983, open forest, V. Davies & J. Gallon (QM S4419); 1♂, Dulacca, 1 May 1928, J.C. Doherty (QM S4362); 1♂, mid-east Qld, Homevale, 1–7 April 1975, Riverine forest (QM S4375); 1♂, Upper Brookfield, CNVF with *Araucaria*, March–April 1981, pitfall, V. Davies & R. Raven (QM S4330); 2♂♂, 1♀, as previous, 3–18 March 1981 (QM S4312); 1♂, as previous, 13 February–3 March 1981 (QM S4310); 5♂♂, as previous, 22 December 1980 (QM S4315); 1♀, as previous, 28 January 1981 (QM S4322); 1♂, Flinton Hill, via Ipswich 120 m, rainforest pitfall, 1975–1976, G. & S. Monteith (QM S12201); 2♂♂, 1♀, SE Qld, Cooloola Freshwater Road, 122 m, April 1987, G. & S. Monteith (QM S12202); 1♂, as previous (QM S3781); 1♂, as previous (QM S3778); 2♂♂, 1♀, as previous, 1974–1975 (QM S12105); 4♂♂, as previous (QM S12107); 1♂, as previous (QM S12106); 3♂♂, 1♀, SE Qld, Cooloola, Searys Scrub, 3–7 February 1976, R. Raven & V. Davies (QM S4481); 3♂♂, 1♀, Cooloola, April 1978, G.B.M. (QM S12095); 7♂♂, Cooloola, L. Poona, April 1978, G. Monteith (QM S12096); 1♀, Brisbane, Ferny Grove, March 1971, E. O'Brien (QM S4263); 1♂, 1♀, Brisbane, Mount Coottha, 23 February 1980, R. Raven (QM S3751); 2♂♂, SE Qld, Top of Blackbutt Range, via Benarkin, 396 m, 1974–1975, G. & S. Monteith (QM S12118); 1♂, as previous (QM S12117); 1♂, SE Qld, base of Blackbutt Range, via Benarkin, 240 m, 29 March 1975, rainforest pitfall, G. & S. Monteith (QM S12113); 1♂, 1♀, mid-east Qld, Blackdown Tableland, via Dingo, 1–6 February 1981, R. Raven (QM S3830); 1♂, Curtis Scrub, Canungra Creek, rainforest pitfall, 1976–1977, G. & S. Monteith (QM S12192); 1♂, SE Qld, Braemar State Forest, 4–8 February 1980, R. Raven & Q.M. (QM S4249); 3♂♂, SE Qld, Malaybrook, Bunya, 1–6 March 1976, pitfall, R. Raven & V. Davies (QM 4482); 1♂, 2♀♀, SE Qld, Malaybrook, Bunya National Park, 1–7 March 1976, V. Davies & R. Raven (QM S3841); 1♀, SE Qld, Stanthorpe, The Summit State School, 29 March 1984, W. McKenzie (QM S4443); 1♀, SE Qld, Little Yabba Creek, via Kenilworth, 152 m, rainforest pitfall, 1974–1975, G. & S. Monteith (QM S12099); NEW SOUTH WALES: 1♂, Broken Head, 30 m, 1975–1976, rainforest

pitfall, G. & S. Monteith (QM S12176); 1♂, 1♀, as previous (QM S12169); 2♂♂, as previous (QM S12215); 3♂♂, as previous, 16 February–6 March 1976 (QM S12217); 1♀, northern NSW, Yabba State Forest, 8 September 1974, R. Raven (QM S3782); 1♂, Cherry Tree State Forest, via Mallanganee, rainforest pitfall, 1978–1979, G. & S. Monteith (QM S3764); 2♂♂, 1♀, Kiwarra State Forest near Taree, 31°58'S 152°26'E, 10 February 1980, pitfall, D. Milledge (AM KS6311); 1♂, Saint Ives, 33°44'S 151°10'E, 6 March 1988, J. Muir (AM KS18721).

**Distribution.** Southern Queensland and New South Wales.

*Neostorena* Rainbow*Neostorena torosa* (Simon) n.comb.

Fig. 5a

*Storena torosa* Simon, 1908: 404 (description of ♀):–Rainbow, 1911: 152.–Jocqué, 1991: 91.

**Remark.** Jocqué (1991) supposed this species to belong in the genus *Storosa*. However, the abdominal colour pattern and the type of epigyne indicate that it should be placed in *Neostorena*. Males are needed to corroborate this placement.

**Type material.** HOLOTYPE ♀: Western Australia, Northampton (ZMB 25436, examined).

**Diagnosis.** The female of this species is recognised by the shape of the epigyne with a central depression delimited by parallel lateral margins, a rounded anterior and a straight posterior margin.

**Description**

**Female.** Total length 13.05 mm; carapace 6.44 mm long, 4.09 mm wide.

Colour. Carapace uniform reddish brown; chelicerae, sternum and legs orange brown; abdomen: sepia, dorsum in middle with a longitudinal series of nine pairs of pale spots; densely mottled with pale on remainder of dorsum and sides; venter pale with three interrupted longitudinal sepia stripes.

Eyes: a, 0.25; b, 0.20; c, 0.18; d, 0.25; e, 0.05; f, 0.28; g, 0.13; h, 0.54. MOQ, AW = 1.12×PW; AW = 0.85×L.

Legs: measurements and spination are given in Tables 2 and 3.

Epigyne (Fig. 5a) central concavity delimited by parallel lateral margins, anterior margin rounded, posterior margin straight.

**Distribution.** Known only from the type locality in Western Australia.

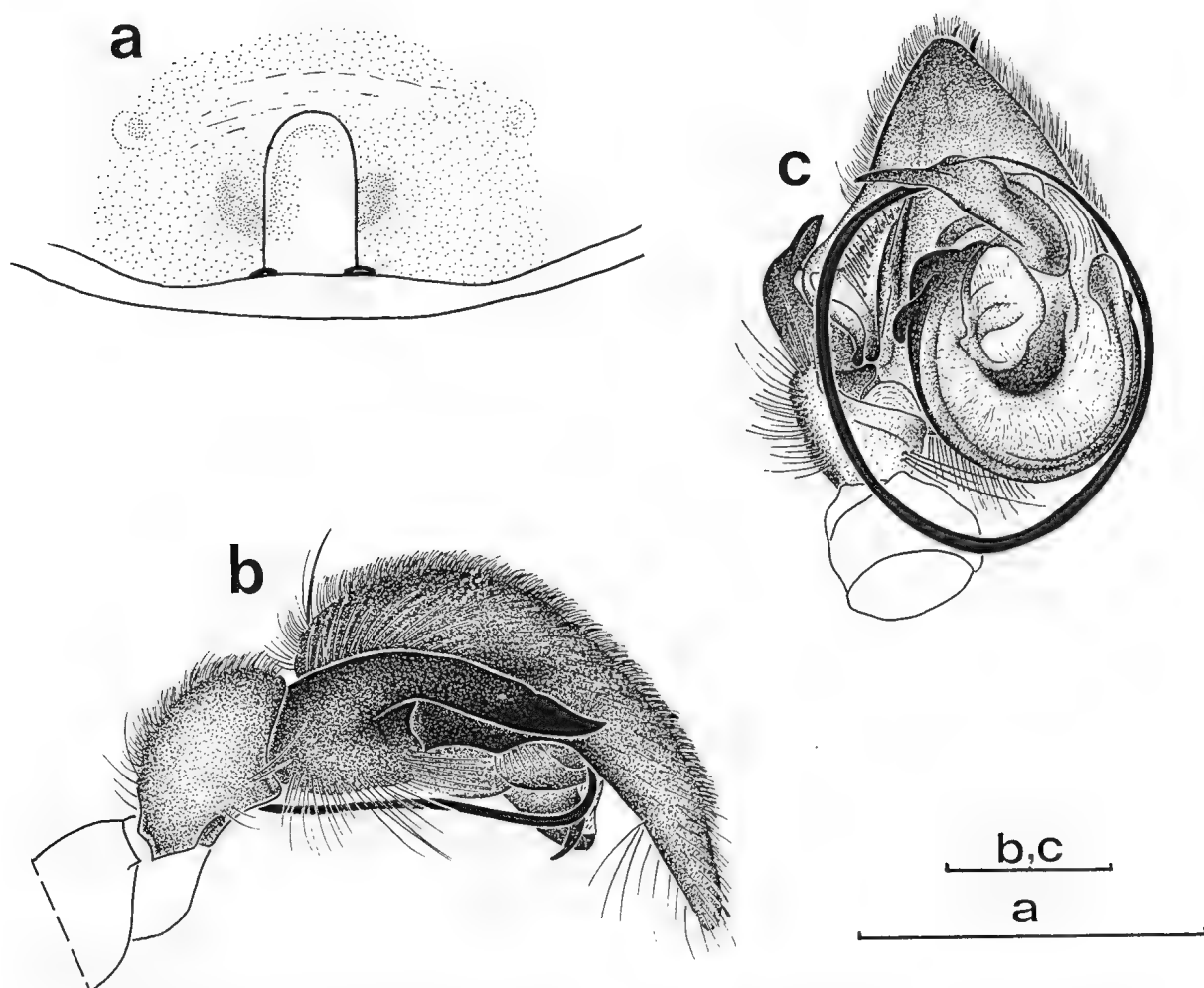


Fig. 5. *Neostorena torosa* (Simon) a, epigyne. *Neostorena vituperata* n.sp. b, male palp, lateral view; c, male palp, ventral view. Scales 1 mm.

*Neostorena vituperata* n.sp.

Fig. 5b,c

**Type material.** HOLOTYPE ♂: north Queensland, Beagle North Camp, N of Aurukun, 13°05'S 141°38'E, 21 March 1981, M. Robinson (AM KS8661). PARATYPES: 1♂, north Queensland, Cooktown, 15°30'S 145°15'E (MNHN); 1♂, north Queensland, 15 km N Moorehead River, 3 September 1982, P. Davie (QM S3776).

**Diagnosis.** Males are recognised by the long pointed tibial apophysis in which the distal part is strongly bent inwards and is provided with a mesoventral denticle, the large cymbial fold with well-developed "exit" and the poorly developed tegular membrane for the largest part hidden by the tegular apophysis. The sternum is strongly rebordered and tarsi and metatarsi are provided with scopulae.

**Etymology.** A specimen of this species was initially chosen to serve as neotype for *N. spirafra*. For a few reasons (type locality, average size) it was not accepted as such whence its name *vituperata* (from Latin "vituperare", to reject).

**Description**

**Male (holotype):** total length 10.44 mm; carapace 6.78 mm long, 4.96 mm wide.

**Colour.** Carapace uniform dark chestnut brown; chelicerae and legs dark brown; sternum dark brown, rebordered along lateral margins, borders black. Abdomen: dorsum sepia, with crescent-shaped white patch in front followed by a series of eight pairs of white spots and one larger spot in front of spinnerets; mottled with white between the spots. Sides mottled with white. Venter pale, with three longitudinal, interrupted dark sepia stripes.

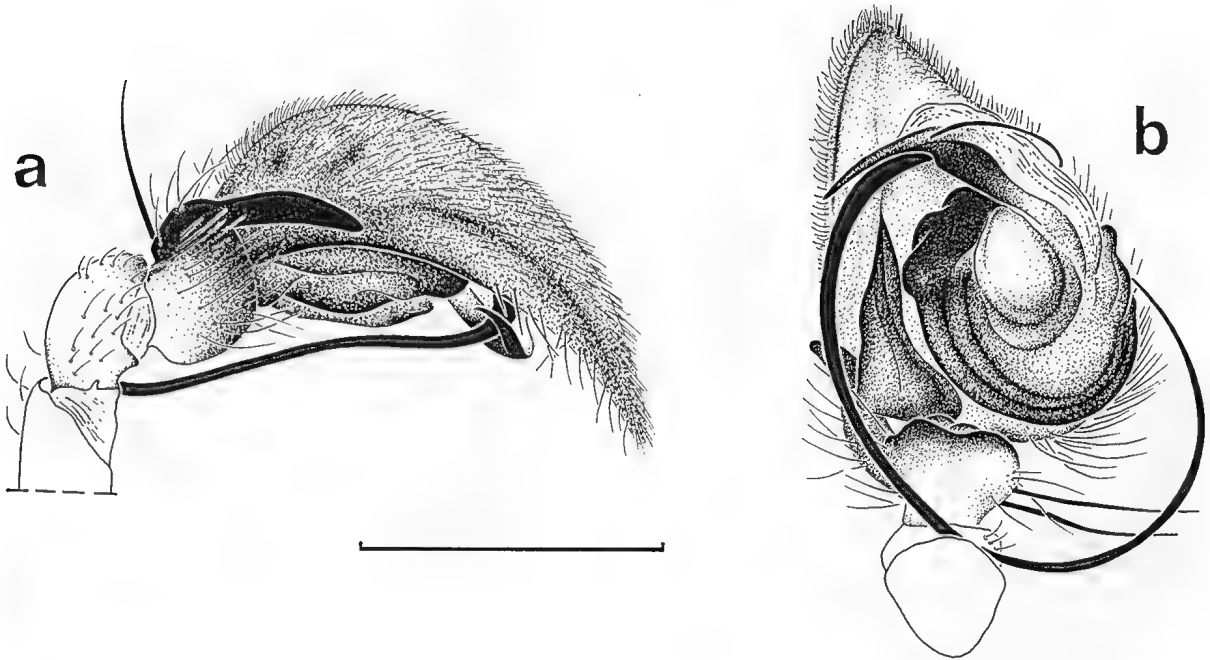


Fig. 6. *Neostorena spirafera* (Koch) a, male palp, lateral view; b, male palp, ventral view. Scales 1 mm.

Eyes: a, 0.16; b, 0.14; c, 0.14; d, 0.14; e, 0.02; f, 0.12; g, 0.04; h, 0.16. MOQ,  $AW = 1.06 \times PW$ ;  $AW = 0.94 \times L$ . Clypeus 0.50 mm high or 3.6 times diameter of ALE.

Legs: measurements and spination are given in Tables 2 and 3. Several long hairs on tibiae, apparently replacing ventral spines. Scopulae well developed on tarsi and distal part of metatarsi.

Male palp (Fig. 5b,c): tibia with fairly long, pointed, lateral apophysis, bent inwards near middle, provided near bent with mesoventral denticle. Cymbium with large lateral fold, "exit" rather rounded, well developed; embolus originating on frontal part of tegulum, describing complete loop; tegular membrane almost completely hidden by tegular apophysis which has thick base, bulging in the middle and with sharp, tapering distal part.

**Distribution.** North Queensland.

*Neostorena spirafera* (Koch) n.comb.

Fig. 6a,b

*Habronestes spirafer* Koch, 1872: 318 (description of ♂)  
not *Habronestes spirafer*.—Van Hasselt, 1887: 227.

**Remark.** The drawing of the male palp provided by Koch (1872, fig. 7d) is puzzling. Close examination reveals that it is a prolateral view; the large dark boss on the cymbium is in fact the large lateral fold and

"exit" that can be seen from the prolateral side. It will therefore remain doubtful whether the specimens here described as *N. spirafera* are really conspecific with that species. However, the specimen described by Koch (1872) is quite small just as the neotype that is here selected. The type locality, "Port Mackay", is likely to be "Mackay" (21°09'S 149°11'E) on the Central Queensland coast. The neotype is from an area about 400 km more to the north.

**Type material.** NEOTYPE ♂: Queensland: The Crater National Park, 17°25'30"S 145°15'E, 23 July–26 November 1992, Qld pitfall NQ27, R. Raven, E. Lawless & M. Shaw (QM S24831).

**Other material examined.** QUEENSLAND: 1♂, 3 juveniles, Davies Creek Road, 17 December 1989, 17°03'S 145°36'E, rainforest, 750 m, Berlese, G. Monteith & G. Thompson (QMS 25699).

**Diagnosis.** *Neostorena spirafera* is a small species in which the male is characterised by the ventral abdominal area with short spines. The long lateral tibial apophysis is dorsoventrally flattened and provided with a short dorsal ridge near the tip.

### Description

**Male (holotype).** Total length 6.56 mm; carapace 3.28 mm long, 2.38 mm wide.

Colour. Carapace and sternum uniform reddish brown; chelicerae and legs orange. Abdomen: dorsum dark grey with faint pattern in which two longitudinal rows of eight small white patches stand out; venter grey with faint pale with white between the spots. Sides mottled with white. Venter pale grey with faint darker pattern. Carapace and sternum reticulated. Abdomen on venter with broad longitudinal area covered with short hairs.

Eyes: a, 0.31; b, 0.27; c, 0.20; d, 0.26; e, 0.06; f, 0.18; g, 0.16; h, 0.40. MOQ, AW = 1.21×PW; AW = 0.93×L. Clypeus 1.05 mm high or 3.9 times diameter of ALE.

Legs: measurements and spination are given in Tables 2 and 3. Several long hairs on tibiae, apparently replacing ventral spines. Scopulae well developed on tarsi and distal part of metatarsi.

Male palp (Fig. 6a,b): tibia with fairly long, pointed, lateral apophysis, bent inwards near middle, provided near bent with mesoventral denticle. cymbium with large lateral fold, "exit" rather rounded, well developed; embolus originating on frontal part of tegulum, describing complete loop; tegular membrane almost completely hidden by tegular apophysis which gas thick base, bulging in the middle and with sharp, tapering distal part.

**Distribution.** North-east Queensland.

### *Neostorena minor* Jocqué

*Neostorena minor* Jocqué, 1991: 67.

**Material examined.** QUEENSLAND: 1♀, SE Qld, The Head via Killarney, 760 m, 18 August–17 November 1974, G. & S. Monteith (QM S12184); 1♀, as previous, 17 November–27 December 1974 (QM S12129); 1♀, as previous, 31 March–2 August 1975 (QM S12124); 1♀, Hoop Pine ?Mount Baldy, Atherton, 1969, C. Plowman (QM S4360); 1♂, SE Qld, Mount Goonaneman, via Childers, 670 m, 31 March–4 September 1977, G. & S. Monteith (QM S12180); 2♂♂, Border Fence, Lever's Flat, 670 m, 1975–1976, G. & S. Monteith (QM S12164); 2♂♂, 1♀, as previous (QM S12162, now in KBIN); 1♂, SE Qld, Moreton Island, Blue Lagoon, 22 September 1982, pitfall, W. Houston (QM 3662); 1♂, SE Qld, Mount Tenison Woods, via Mount Glorious, 762 m, 1975–1976, G. & S. Monteith (QM S12216); 1♀, SE Qld, Brisbane, Gold Creek Reserve, 17 September 1980, R. Raven & V. Davies (QM S4301); 1♂, SE Qld, O'Reillys, Lamington National Park, litter, 28 March 1976, R. Raven (QM S3725); 1♂, as previous, 8–18 July 1977 (QM S3842); 1♀, NE Qld, Windin Falls, NW of Mount Bartle-Frere, 580 m, 9 October 1980, berlese, G. Monteith (QM S3737); 1♀, SE Qld, Mount Chingee, 12 km SE Rathdowney, 720 m, 17 December 1982, rainforest litter, Monteith et al. (QM S4240); 1♂, SE Qld, Upper Tallebudgera Valley, 530 m, March–July 1985, D. Cook (QM S4262); 1♀, SE Qld, Upper Tallebudgera Valley, Below Springbrook, 300 m, 8 January–17 March 1985, Monteith et al. (QM S5254); 1♂, as previous (QM S4281); 1♀, SE Qld, Balvis Scrub, litter, 30 April 1980, G. Monteith (QM S3858); 1♂, Mistake Mountains, via Goomburra, 1040 m, rainforest pitfall, 1976–1977, G. & S. Monteith (QM S12185); 1♀, SE Qld, Bald Mountain, via Emu Vale, G. & S. Monteith (QM

S12122); 1♂, as previous, 17 february–28 December 1974 (QM S12123); 1♂, Burpengary Creek, via Caboolture, rainforest pitfall, 1977–1978, G. & S. Monteith (QM S12199); 1♂, Mount Mee Plateau Site, 550 m, rainforest pitfall, 1977–1978, G. & S. Monteith (QM S12196); 1♂, Upper Brookfield, CNVF with *Araucaria*, 14–28 November 1980, pitfall, V. Davies & R. Raven (QM S4314); 1♂, as previous, 15 October 1980 (QM S4313); 1♂, as previous, 28 November–11 December 1980 (QM S4328); 1♂, as previous, 30 October 1980 (QM S4327); 3♀♀, SE Qld, Mount Hobwe, Lamington National Park, 3–8 April 1976, pitfall, R. Raven & V. Davies (QM S4479); 2♂♂, Binna Burra, Lamington National Park, 30 March 1976, V. Davies & R. Raven (QM S3852); 1♂, SE Qld, Top of Blackbutt Range, via Benarkin, 396 m, 1974–1975, G. & S. Monteith (QM S12116); 1♂, base of Blackbutt Range, via Benarkin, 244 m, rainforest pitfall, 1974–1975, G. & S. Monteith (QM S12115); 2♂♂, SE Qld, Cunningham's Gap, 762 m, rainforest pitfall, 1974–1975, G. & S. Monteith (QM S12136); 3♂♂, Philp Farm, Lever's Flat, via Rathdowney, 640 m, rainforest pitfall, 1975–1976, G. & S. Monteith (QM S12218); 1♂, SE Qld, Casey Creek, via Imbil, 90 m, rainforest pitfall, 1974–1975, G. & S. Monteith (QM S12101); 1♂, SE Qld, Mary Cairncross Park, 488 m, rainforest pitfall, 1974–1975, G. & S. Monteith (QM S12097); 1♀, NEQ, Mount Edith, Lamb Range, 1050 m, 12 October 1982, rainforest litter, berlese, Monteith et al. (QM S3801); 1♀, Lake Broadwater, via Dalby, pitfalls site 3, 17 May–24 November 1985, QM & M. Bennie (QM S15730). NEW SOUTH WALES: 2♂♂, Toonumbar State Forest, via Grévillea, 610 m, rainforest pitfall, 17 November–27 December 1974, G. & S. Monteith (QM S12132); 1♂, Toonumbar State Forest, via Grevillea, 610 m, rainforest pitfall, 1974–1975, G. & S. Monteith (QM S12194); 1♂, as previous (QM S12130); 2♂♂, New Brighton Beach, via Brunswick Heads, 10 m, rainforest pitfall, 1974–1975, G. & S. Monteith (QM S12214); 1♂, as previous (QM S12140); 1♀, northern NSW, Tooloom Scrub, rain forest litter, 28 April 1983, G. Thompson (QM 4273); 1♂, 1♀, NE NSW, Nothofagus Mountain, via Woodenbong, 1100 m, 17 June 1982, berlese, *Nothofagus* litter, G. Monteith & G. Thompson (QM S4252).

**Distribution.** Queensland, New South Wales.

### *Mallinella* Strand

#### *Mallinella zebra* (Thorell) n.comb.

Fig. 7a–d

*Storena zebra* Thorell, 1881: 184 (description of ♂).—Strand, 1911: 132.—Hogg, 1915: 439.

**Type material.** Holotype ♂: Aru Islands, Vakan, O. Beccari (MCSNG) (examined).

**Other material examined.** NEW GUINEA: 7♂♂, Mundiaptera 1962, B. Monulf (RMNH 8145). AUSTRALIA, QUEENSLAND: 1♂, Iron Range Cape York, 9 July 1971, G. Monteith (QM S3713); 2♂♂, 2♀♀, Lowland and Highland, Lamond Hill from RNNEQ, 25 June–6 July 1976, pitfall, R. Raven & V. Davies (QM S4474); 1♂, 1♀, NNEQ, East Claudie Scrub, Iron Rabge, 25 June 1976 (QM S4473).

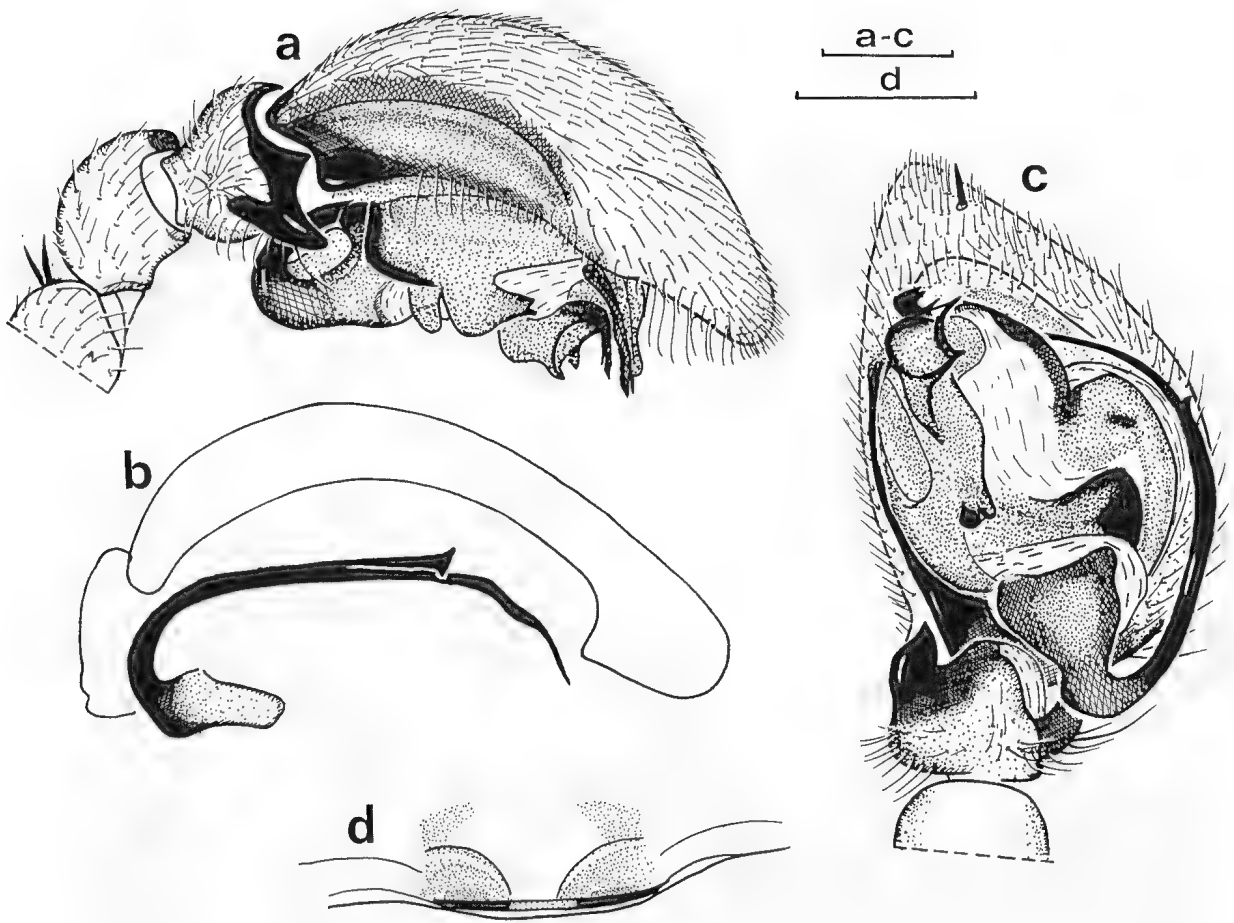


Fig. 7. *Mallinella zebra* (Thorell): a, male palp, lateral view; b, male palp, mesal view, showing split embolus; c, male palp, ventral view; d, epigyne. Scales 0.5 mm.

**Diagnosis.** The male is easily recognised by the characteristics of its palp i.e. the embolus with partly split section ending in a transverse tooth and the details of tegular apophysis and conductor.

### Description

**Male.** Total length 6.29 mm; carapace 3.33 mm long, 2.29 mm wide.

**Colour.** Carapace and chelicerae dark brown; sternum orange; legs yellowish orange. Abdomen sepia with two rows of three pale spots on posterior part of dorsum and two oblique pale stripes on sides; venter pale.

**Eyes:** a, 0.25; b, 0.13; c, 0.15; d, 0.16; e, 0.10; f, 0.07; g, 0.31; h, 0.31. MOQ,  $AW = 1.30 \times PW$ ;  $AW = 1.00 \times L$ . Clypeus straight; 0.71 mm high or 5.46 times width of ALE.

**Legs:** measurements and spination are given in Tables 2 and 3.

**Male palp (Fig. 7a-c):** tibia with short, strong, downcurved prolateral apophysis; cymbial fold reaching to  $2/3$  length of cymbium; embolus originating on posterior part of tegulum, split over  $1/4$  of its length

(Fig. 7b), the short part with a transversal tooth at its extremity; tegular apophysis with one short proximal tooth, one double tooth in middle and fine prong at tip; conductor with two narrow prongs distally.

**Female (QM S4474).** Total length 6.52 mm; carapace 3.02 mm long, 2.13 mm wide.

**Colour.** Carapace and chelicerae medium brown; sternum orange; legs yellowish orange with darker stripes on femora. Abdomen grey with three pale spots in front of spinnerets on dorsum, sides uniform greyish sepia; venter grey mottled with pale in front.

**Eyes:** a, 0.20; b, 0.18; c, 0.16; d, 0.20; e, 0.05; f, 0.10; g, 0.16; h, 0.25. MOQ,  $AW = 1.05 \times PW$ ;  $AW = 0.81 \times L$ . Clypeus straight; 0.73 mm high or 4.05 times width of ALE.

**Legs:** measurements and spination are given in Tables 2 and 3.

**Epigyne (Fig. 7d)** very simple, just a transversal slit with spermathecae shining through.

**Distribution.** New Guinea and north Queensland.



*Nostera* Jocqué

**Remarks.** The generic definition of *Nostera* Jocqué is here widened to enable the inclusion of species with a slender embolus. According to the original diagnosis by Jocqué (1991), *Nostera* males have a short, straight embolus originating on the anterior part of the tegulum. It is clear from the studies of Jocqué & Baehr (1992) and Baehr & Jocqué (1994) that within a genus, namely *Storena*, the palpal structure can change extensively although the basic conformation remains the same. In that genus the most plesiomorphic species have a short straight, self-supporting embolus, inserted on the distal end of the tegulum. In the course of the evolution the embolus becomes long and slender which results in insertion further back on the tegulum and the development of one or more tegular apophyses which function as conductors. The former stage is similar to what is found in *Nostera lynx* Jocqué whereas the situation in *N. nadgee* n.sp. can be compared with that in the more apomorphic species of *Storena*. However, whereas *Storena* is easily defined by its somatic characters, this is not the case with *Nostera* which may be regarded as a plesiomorphic genus, difficult to define. It may prove to be polyphyletic but it will need a thorough revision to conclude that the species placed in it do indeed belong to the same genus.

**Diagnosis.** Representatives of this genus have three rows of trichobothria on the tibiae; males are recognised by the simple male palpal tibia with distal retrolateral apophysis, the cymbium with proximal lateral flange and by the basic palpal conformation with a laterally inserted embolus and a membranous distal tegular apophysis, sometimes with an additional sclerified apophysis when the embolus is long and slender. Females have an epigynum with central membranous area; the entrance ducts begin at its anterior edge and lead to a pair of large spermathecae on the posterior rim of the epigyne.

*Nostera leucosema* (Rainbow) n.comb.

Fig. 8a

*Storena leucosema* Rainbow, 1920: 237 (description of ♀).

**Remarks.** The placement of this species in *Nostera* is tentative; in the absence of males there is no real clue as to what genus it belongs. However, it cannot be included any longer in *Storena* as that genus is now well defined (Jocqué & Baehr, 1992). The somatic characters match more or less those of *Nostera* but the lack of teeth on the chelicerae prompts caution. There is also some resemblance to *Neostorena*, but in that genus the chilum is always clearly double.

**Type material.** LECTOTYPE ♀ (by present designation): Australia, NSW, Lord Howe Island, top of Mount Gower K 39461 (AM KS6685) (examined). PARALECTOTYPES: 2 juveniles together with lectotype.

**Other material examined.** LORD HOWE ISLAND: 1♀, North Hill, 130 m, 17–28 May 1980, S. & J. Peck, dung cup traps, lowland forest (AMNH); 1♀, 2 juveniles, as above, Stephens Reserve 25 May 1980, litter under bark (AMNH); 1♀, 31°33'S 159°05'E, February 1971 (SAM, AM KS15672).

**Diagnosis.** The females of this species differ from other *Nostera* by the lack of teeth on the promargin of the chelicerae.

**Description**

**Female.** Total length 6.50 mm; carapace 3.58 mm long, 2.37 mm wide.

Colour. Carapace reddish brown, somewhat paler in front of fovea; chelicerae reddish brown, sternum orange; legs: femora, patellae, tibiae and base of metatarsi yellow, remainder orange. Abdomen pale sepia; dorsum with white patches in posterior half; a pair of crescent-shaped ones followed by two smaller oval ones and a single larger patch in front of the spinnerets; in some specimens there are two large extra patches in front.

Eyes: a, 1.00 (0.11); b, 1.18; c, 1.22; d, 1.18; e, 0.45; f, 0.82; g, 0.72; h, 1.72. MOQ, AW = 0.77×PW; AW = 0.67×L. Clypeus 0.42 mm high or c. 3 times the diameter of an ALE, convex with few small hairs. Chilum double, two narrow sclerites connected dorsally by narrow strip. Chelicerae with anteromesal scopula, without teeth.

Legs: measurements and spination are given in Tables 2 and 3. Metatarsi with distal hair tufts.

Abdomen oval; spinnerets 6; no row of spines in front of spinnerets. Tracheal spiracle crescent-shaped.

Epigyne (Fig. 8a) a poorly sclerotised flat area with only posterior rim darkened; coiled spermathecae near posterior margin shining through.

**Male.** Unknown.

**Distribution.** Lord Howe Island.

*Nostera nadgee* n.sp.

Fig. 8b–d

**Remarks.** Although the aim of the present paper is not to describe new species, I thought it necessary to describe this taxon as it occurs together with *Nostera leucosema* on Lord Howe Island. The latter species is only known from females and has a similar size and colour pattern. I therefore initially thought that the males of *N. nadgee* were those of *N. leucosema* until I matched the correct females.

**Type material.** HOLOTYPE ♂: Australia, NSW, Nadgee Nature Reserve 37°27'S 149°56'E, 24 May 1978, pitfall, G. Gowing (AM ex KS 1609). PARATYPES: 16♂♂, together with holotype (AM KS37842).



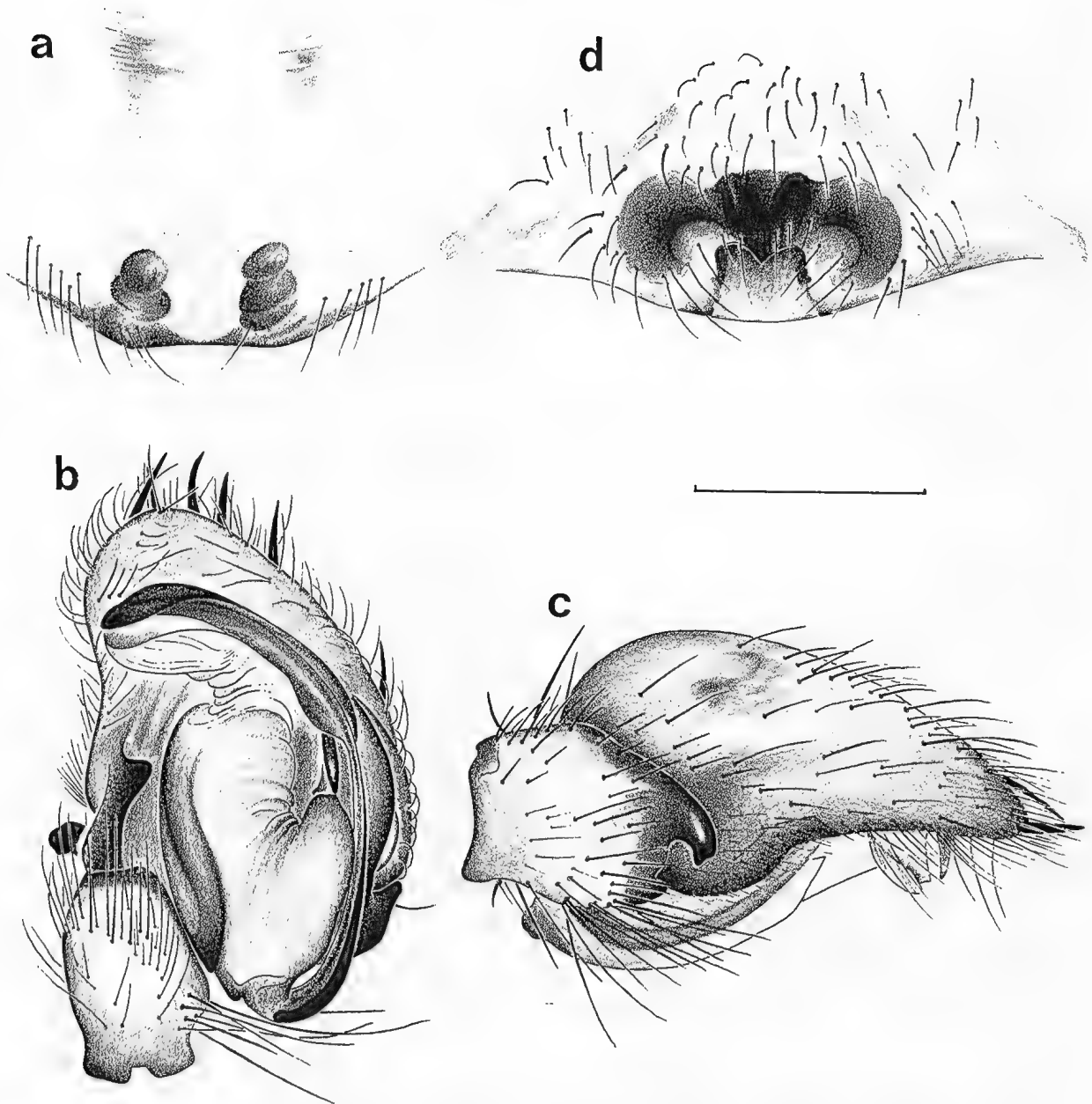


Fig. 8. *Nostera leucosema* (Rainbow): a, epigyne, ventral view. *Nostera nadgee* n.sp. b, male palp, lateral view; c, male palp, lateral view; d, epigyne, ventral view. Arrows show course of entrance ducts. Scale 0.5 mm.

**Other material examined.** LORD HOWE ISLAND: 1♀, Transit Hill, c. 110 m, 17 May 1980, berlese rotting wood, tall forest, S. & J. Peck (AMNH); 1♀, North Hill, c. 260 m, berlese rotting wood, low forest, 17 May 1980, S. & J. Peck (AMNH); 1♂, 2♀♀, many juveniles, Roach Island, 27 May 1980, berlese of litter in seabird burrows and rock crevices, S. & J. Peck (AMNH); 1♂, 31°33'S 159°05'E, February 1971, in moist log, M. Gray (AM KS15565). QUEENSLAND: 3♂♂, NE Qld, Spear Creek, near Mount Molloy, 16°42'S 145°24'E, 3–10 November 1975, pitfall in notophyll vine forest, R. Raven & V. Davies (QM S4461). NEW SOUTH WALES: 1♂, Cuningar via Harden, 34°34'S 148°25'E, 20 June 1979, N. Pigram (AM KS3086); 1♂, Neutral Bay, 9 June 1981, L. Hopwood (AM

KS9566); 1♂, Castle Hill, 33°44'S 151°00'E, 25 June 1980 (AM KS5339).

**Diagnosis.** The females of this species differ from other *Nostera* by the epigyne with central depression of which the anterior margin has a protruding rounded lip; the male is recognised by the short tibial apophysis, strongly curved down and with a truncated, slightly indented tip.

**Etymology.** *Nadgee* is a noun in apposition taken from the type locality.

### Description

**Male.** Total length 5.62 mm; carapace 3.06 mm long, 2.13 mm wide.

**Colour.** Carapace uniform medium brown, with very faint radiating striae. Somewhat paler in front of fovea; chelicerae reddish brown, sternum orange; legs yellowish orange, femora markedly darker. Abdomen sepia; dorsum with 1 pair of white spots in front, separated by narrow pale brown scutum; followed by seven pale chevrons, the frontal one sometimes divided into two spots; sides sepia mottled with white and with two oblique stripes in posterior half; venter pale with two ill-defined longitudinal pale sepia stripes.

**Eyes:** a, 0.12; b, 0.15; c, 0.11; d, 0.13; e, 0.03; f, 0.05; g, 0.05; h, 0.13. MOQ, AW = PW; AW = 0.73×L. Clypeus 0.20 mm high or 1.33 times the diameter of an ALE, almost straight, with few small hairs. Chilum single. Chelicerae with anteromesal scopula, with two teeth on anterior margin.

**Legs:** measurements and spination are given in Tables 2 and 3.

**Male palp** (Fig. 8b,c): palpal tibia with short downcurved apophysis, tip truncated and finely indented. Tegulum with well-developed terminal membrane and large conductor-like sclerite originating mesodorsally on posterior part of tegulum; embolus thin and relatively short, originating far back on tegulum.

**Female** (from Transit Hill). Total length 7.24 mm; carapace 2.94 mm long, 1.87 mm wide.

**Colour.** As in male; femora not darker than remainder of legs but these darker towards tarsus; oblique stripes on sides of abdomen larger and sometimes three in stead of two.

**Eyes:** a, 0.11; b, 0.14; c, 0.10; d, 0.13; e, 0.02; f, 0.03; g, 0.02; h, 0.11. MOQ, AW = 1.09×PW; AW = 0.73×L. Clypeus 0.19 mm high or 1.36 times the diameter of an ALE, straight, with few small hairs. Chilum single. Chelicerae with two teeth on anterior margin.

**Legs:** measurements and spination are given in Tables 2 and 3.

**Epigyne** (Fig. 8d) with well delimited central depression; its anterior margin with protruding and rounded lip.

**Variation.** There is a large size variation in this species. By far the largest specimens are those from Roach Island (male, total length 6.73 mm, carapace width 2.43 mm, length 3.41 mm); the males from New South Wales are smaller (total length 4.77–6.39 mm, carapace width 1.79–2.30 mm, length 2.60–3.41 mm) whereas those from Queensland are very small (total length 3.83–4.34 mm; carapace width 1.32–1.49 mm, length 2.00–2.17 mm).

**Distribution.** Lord Howe Island, New South Wales and Queensland.

### *Nostera lynx* Jocqué

*Nostera lynx* Jocqué, 1991: 72.

**Material examined.** QUEENSLAND: 1♂, Sarabah National Park, via Canungra, 120 m, 1976–1977, G. & S. Monteith (QM S12173); 1♂, Plateau south of The Head, via Killarney, pitfall 21, 17 February–27 December 1974, G. & S. Monteith (QM S12167); 1♂, as previous, 17 November–27 December 1974 (QM S12129); 2♀♀, The Head, via Killarney, 760 m, pitfall, 1974, G. & S. Monteith (QM S12128); 1♀, SE Qld, Teviot Falls, via Boonah, 820 m, 1976–1977, G. & S. Monteith (QM S12211); 1♀, SE Qld, Lamington Plateau, 21 April 1975, R. Raven (QM 4437); 1♂, SE Qld, Plateau south of The Head, via Killarney, 18 August–17 November 1974, pitfall, G. & S. Monteith (QM S12125); 1♀, SE Qld, Binna Burra, 25 June 1966, leaf litter, C. Plowman (QM S4395); 1♂, Binna Burra, Lamington National Park, 30 March 1976, V. Davies & R. Raven (QM S3852); 2♀♀, as previous, 27 March 1976 (QM S4477); 1♀, SE Qld, Rozen's Lookout, Beechmont, 448 m, rainforest pitfall, 1974–1975 G. & S. Monteith (QM S12190); 1♂, SE Qld, Bald Mountain, via Emu Vale, G. & S. Monteith (QM S12120); 2♂♂, as previous, 17 November–28 December 1974 (QM S12123); 1♂, 1♀, as previous (QM S12121); 1♂, O'Reillys, Lamington National Park, 17 March 1981, J. Stanisc & D. Potter (QM S4409); 1♂, O'Reillys, Lamington National Park, 15 November 1977, by night, YED, ED & R. Raven (QM S4475); 1♂, Cainbale, via Lamington National Park, 762 m, rainforest pitfall, 1975–1976, G. & S. Monteith (QM S12204); 1♂, Tamborine, Palmgrove, 26 October–14 December 1974, pitfall, G. & S. Monteith (QM S12138). NEW SOUTH WALES: 2♀♀, Mount Glennie, 16 km E Woodenbong, 910 m, 25 November 1982, rainforest litter, berlese, Monteith et al. (QM S4237); 1♂, Toonumbar State Forest, via Grevillea, 610 m, rainforest pitfall, 1974–1975, G. & S. Monteith (QM S12194).

**Distribution.** Queensland and New South Wales.

### *Hetaerica* Rainbow

#### *Hetaerica variegata* (Pickard-Cambridge)

*Storena variegata* Pickard-Cambridge, 1869: 53 (description of juvenile).

*Habronestes variegatus*—Koch, 1872: 302 (description of juvenile).

**Remarks.** Although both Pickard-Cambridge (1869) and Koch (1872) stated that they had described adult females, the holotype (UMO, examined) is clearly a juvenile. Hickman (1950) designated a "cotype" (NVM, examined) for this species which is a female. As there is no evidence that the juvenile holotype and the specimen described by Hickman are conspecific, we regard the designation of a cotype, as well as his identification, as invalid. If one also considers that it is impossible to identify the genus as the type species *Hetaerica aresca* Rainbow is also known only from juveniles (see Jocqué, 1991: 60) it is decided here to invalidate both species and the genus *Hetaerica*.

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**Table 1.** List of Australian Zodariidae described before Jocqué (1991). Annotation: 1, paratype status; 2, synonym of *Storena cyanea*.

species	author	year	initial genus	present genus	type depository	type status
<i>annulipes</i>	Koch	1867	<i>Enyo</i>	<i>Habronestes</i>	ZMH	juv
<i>aresca</i>	Rainbow	1916	<i>Hetaerica</i>	<i>Hetaerica</i>	AM	juv
<i>australiensis</i>	Pickard-Cambridge	1869	<i>Storena</i>	<i>Habronestes</i>	UMO	♀
<i>braccata</i>	Koch	1867	<i>Enyo</i>	?	ZMH	juv
<i>bradleyi</i>	Pickard-Cambridge	1869	<i>Storena</i>	<i>Habronestes</i>	UMO	♂
<i>colossea</i>	Rainbow	1920	<i>Storena</i>	<i>Storena</i>	SAMA	?
<i>cyanea</i>	Walckenaer	1805	<i>Storena</i>	<i>Storena</i>	AM	♂
<i>eximia</i>	Simon	1908	<i>Storena</i>	<i>Storena</i>	ZMB	juv <sup>1</sup>
<i>flavipedes</i>	Urquhart	1893	<i>Habronestes</i>	?	lost	
<i>formosa</i>	Thorell	1870	<i>Storena</i>	<i>Storena</i>	NRS	♀
<i>graeffei</i>	Koch	1867	<i>Storena</i>	?	ZMH	juv
<i>grimwadei</i>	Dunn	1951	<i>Storena</i>	<i>Habronestes</i>	NVM	♀
<i>inornata</i>	Rainbow	1916	<i>Storena</i>	?	lost	
<i>leucosema</i>	Rainbow	1920	<i>Storena</i>	<i>Nostera</i>	AM	♂
<i>macedonensis</i>	Hogg	1900	<i>Storena</i>	<i>Habronestes</i>	BMNH	♂
<i>maculata</i>	Pickard-Cambridge	1869	<i>Storena</i>	?	UMO	juv
<i>ornatus</i>	Bradley	1878	<i>Habronestes</i>	?	lost	
<i>picta</i>	Koch	1865	<i>Enyo</i>	?	lost	
<i>procera</i>	Thorell	1890	<i>Storena</i>	<i>Storena</i>	NRS	♀ <sup>2</sup>
<i>rastellata</i>	Strand	1913	<i>Storena</i>	?	SMF	juv
<i>rufescens</i>	Thorell	1881	<i>Storena</i>	?	lost	
<i>scenica</i>	Koch	1872	<i>Habronestes</i>	<i>Australorena</i>	ZMH	♀
<i>scintillans</i>	Pickard-Cambridge	1869	<i>Storena</i>	<i>Chilumena</i>	UMO	♀
<i>spirafera</i>	Koch	1872	<i>Habronestes</i>	<i>Neostorena</i>	lost	
<i>striatipes</i>	Koch	1872	<i>Habronestes</i>	<i>Habronestes</i>	ZMH	♀
<i>tetrica</i>	Simon	1908	<i>Storena</i>	<i>Storosa</i>	ZMB	♀
<i>toddi</i>	Hickmann	1944	<i>Storena</i>	<i>Habronestes</i>	AM	♂
<i>torosa</i>	Simon	1908	<i>Storena</i>	<i>Neostorena</i>	ZMB	♀
<i>tricolor</i>	Simon	1908	<i>Storena</i>	?	ZMH	juv
<i>variegata</i>	Pickard-Cambridge	1869	<i>Storena</i>	?	UMO	juv
<i>venatoria</i>	Rainbow	1914	<i>Neostorena</i>	<i>Neostorena</i>	AM	juv
<i>zebra</i>	Thorell	1881	<i>Storena</i>	<i>Mallinella</i>	MCSNG	♂

**Table 2.** Leg measurements. F—femur; P—patella; T—tibia; Mt—metatarsus; t—tarsus; Tot—total.

	F	P	T	Mt	t	Tot
<i>Habronestes bradleyi</i> (Pickard-Cambridge)						
I	1.88	0.71	1.67	1.88	?	6.14
II	1.88	0.71	1.50	1.88	1.38	7.35
III	1.88	0.71	1.50	1.75	1.41	7.25
IV	2.54	0.75	2.25	3.54	1.82	10.90
<i>Habronestes grimwadei</i> (Dunn) n.comb.						
I	1.83	0.58	1.50	1.71	1.29	6.91
II	1.88	0.62	1.42	1.79	1.29	7.00
III	1.63	0.57	1.34	1.85	1.32	6.71
IV	2.63	0.71	2.25	3.54	1.87	11.00

Continued...

Table 2. Continued.

	F	P	T	Mt	T	Tot
<i>Habronestes toddi</i> (Hickman) n.comb.						
I	1.75	0.62	1.46	1.67	1.12	6.62
II	1.71	0.62	1.33	1.54	1.00	6.20
III	1.67	0.62	1.25	1.75	0.91	6.20
IV	2.04	0.58	1.63	2.38	1.21	7.84
<i>Storosa tetrica</i> (Simon) n.comb.						
I	2.71	1.08	2.17	2.00	1.46	9.42
II	2.37	1.08	1.75	1.71	1.25	8.16
III	2.16	1.00	1.33	2.04	1.12	7.65
IV	2.75	1.16	2.08	3.08	1.50	10.57
<i>Neostorena torosa</i> (Simon) n.comb.						
I	3.62	1.44	2.60	2.39	1.45	11.50
II	3.07	1.44	2.00	1.83	1.15	9.49
III	2.64	1.28	1.75	2.17	1.02	8.86
IV	3.58	1.62	2.56	3.24	1.28	12.28
<i>Neostorena vituperata</i> n.sp.						
I	4.04	1.79	3.32	3.28	2.13	14.56
II	3.41	1.75	2.26	2.60	1.49	11.51
III	3.19	1.49	1.83	2.85	1.32	10.68
IV	4.17	1.70	2.98	4.38	1.62	14.85
<i>Neostorena spirafra</i> (Koch) n.comb.						
I	2.00	0.85	1.51	1.45	0.95	6.76
II	1.80	0.85	1.25	1.30	0.90	6.10
III	1.60	0.85	1.00	1.50	0.75	5.70
IV	2.15	0.95	1.50	2.25	0.95	7.80
<i>Mallinella zebra</i> (Thorell) n.comb. (♂)						
I	2.50	0.87	2.37	2.54	1.71	9.99
II	2.41	0.87	2.08	2.37	1.58	9.31
III	2.29	0.87	1.92	2.33	1.46	8.87
IV	2.71	0.92	2.50	3.46	2.21	11.80
<i>Mallinella zebra</i> (Thorell) n.comb. (♀)						
I	2.04	0.77	1.83	1.92	1.61	8.17
II	2.00	0.77	1.49	1.83	1.28	7.37
III	1.92	0.81	1.53	2.00	1.28	7.54
IV	2.39	0.81	2.26	3.19	1.70	10.35
<i>Nostera leucosema</i> (Rainbow) n.comb.						
I	2.50	0.87	2.08	2.21	1.42	9.08
II	2.13	0.96	1.63	1.87	1.21	7.80
III	1.96	0.96	1.47	1.83	1.00	7.22
IV	2.58	0.96	2.08	2.83	1.33	9.78
<i>Nostera nadgee</i> n.sp. (♂)						
I	2.37	0.93	1.71	1.54	1.03	7.58
II	1.92	0.82	1.34	1.44	0.93	6.45
III	1.83	0.89	0.87	1.71	1.03	6.33
IV	2.27	0.95	1.48	2.47	1.19	8.36
<i>Nostera nadgee</i> n.sp. (Transit Hill ♀)						
I	1.58	0.89	1.28	0.98	0.68	5.41
II	1.45	0.77	0.98	1.94	0.60	5.74
III	1.28	0.77	0.85	1.11	0.68	4.69
IV	1.70	0.81	1.15	1.70	0.89	6.25

**Table 3.** Leg spination; *d*—dorsal, *disp*—dispersed, not in obvious rows, *dw*—distal whorl, *pl*—prolateral, *rl*—retrolateral, *v*—ventral.

	femur	patella	tibia	metatarsus
<b><i>Habronestes bradleyi</i> (Pickard-Cambridge)</b>				
I	<i>d</i> 1-1	—	<i>d</i> 1 <i>pl</i> 1 <i>rl</i> 1 <i>v</i> 1-1-2	<i>v</i> 1-1-1-2
II	<i>d</i> 1-1	<i>pl</i> 1	<i>d</i> 1 <i>pl</i> 1 <i>rl</i> 1 <i>v</i> 1-1-2	<i>v</i> 12
III	<i>pl</i> 1 <i>d</i> 3* <i>rl</i> 1	<i>rl</i> 1-1	<i>pl</i> 1-1 <i>d</i> 3* <i>rl</i> 3* <i>v</i> 1-2-1-2	24 <i>disp</i>
IV	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 1	<i>pl</i> 1 <i>rl</i> 1	<i>pl</i> 1 <i>d</i> 1-1 <i>rl</i> 1-1 <i>v</i> 2-2-1-2	22 <i>disp</i>
<b><i>Habronestes grimwadei</i> (Dunn) n.comb.</b>				
I	<i>pl</i> 1 <i>d</i> 3* <i>v</i> 6*	<i>pl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>v</i> 1-1-2	<i>v</i> 1-1-1-2
II	<i>pl</i> 1 <i>d</i> 3* <i>v</i> 6*	<i>pl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>v</i> 1-1-2	<i>v</i> 1-1-1-2
III	<i>d</i> 3* <i>rl</i> 1 <i>v</i> 3*	<i>pl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>v</i> 2-2-2	16 <i>disp</i>
IV	<i>d</i> 3* <i>rl</i> 1 <i>v</i> 1	<i>pl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 1 <i>v</i> 2-2-2	12 <i>disp</i>
<b><i>Habronestes toddi</i> (Hickman) n.comb.</b>				
I	<i>pl</i> 1 <i>d</i> 2*	—	<i>pl</i> 2* <i>d</i> 2* <i>rl</i> 1	8 <i>disp</i>
II	<i>pl</i> 1 <i>d</i> 3*	—	<i>pl</i> 2* <i>d</i> 2* <i>rl</i> 1	9 <i>disp</i>
III	<i>pl</i> 2 <i>d</i> 3* <i>rl</i> 1	<i>d</i> 5	8 <i>disp</i>	10 <i>disp</i>
IV	<i>pl</i> 1 <i>d</i> 3*	<i>d</i> 5	8 <i>disp</i>	10 <i>disp</i>
<b><i>Storosa tetrica</i> (Simon) n.comb.</b>				
I	<i>d</i> 1	—	<i>v</i> 1-1-2	<i>v</i> 2-2-2
II	<i>d</i> 1	—	<i>v</i> 1-1-2	<i>v</i> 2-2-2
III	<i>d</i> 1-1-2	<i>pl</i> 1-1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 2* <i>v</i> 2-2-2	<i>disp</i> 16
IV	<i>d</i> 3*	<i>pl</i> 2* <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 4* <i>rl</i> 2* <i>v</i> 2-2-2	<i>disp</i> 16
<b><i>Neostorena torosa</i> (Simon) n.comb.</b>				
I	<i>pl</i> 1 <i>d</i> 2*	—	<i>v</i> 1-1-2	<i>v</i> 2-2-3
II	<i>pl</i> 1 <i>d</i> 2*	—	<i>v</i> 1-1-2	<i>v</i> 2-2-3
III	<i>pl</i> 1 <i>d</i> 3* <i>rl</i> 1	<i>pl</i> 2 <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 2* <i>v</i> 1-2-2	10 <i>disp</i> <i>dw</i> 6
IV	<i>pl</i> 1 <i>d</i> 3* <i>rl</i> 1	<i>pl</i> 2 <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 3* <i>d</i> 3* <i>rl</i> 3* <i>v</i> 2-2-2	12 <i>disp</i> <i>dw</i> 6
<b><i>Neostorena vituperata</i> n.sp.</b>				
I	<i>pl</i> 1 <i>d</i> 2*	—	<i>v</i> 1-1-2	<i>v</i> 1-2 <i>dw</i> 4
II	<i>pl</i> 1 <i>d</i> 2*	—	—	<i>v</i> 2 <i>dw</i> 4
III	<i>pl</i> 1 <i>d</i> 2* <i>rl</i> 1	<i>pl</i> 5 <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 1-1-2 <i>rl</i> 2* <i>v</i> 2-2-2	8 <i>disp</i> <i>dw</i> 6
IV	<i>d</i> 3* <i>rl</i> 1	<i>pl</i> 7 <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 1-1-1-2 <i>rl</i> 2 <i>v</i> 2-1-2	8 <i>disp</i> <i>dw</i> 6
<b><i>Neostorena spirafra</i> (Koch) n.comb.</b>				
I	<i>d</i> 1	—	<i>v</i> 1-1-2-1-1	<i>v</i> 2-2 <i>dw</i> 3
II	<i>d</i> 1	—	<i>v</i> 1-1-1	<i>v</i> 2 <i>d</i> -2 <i>w</i> 3
III	<i>d</i> 1	<i>pl</i> 2 <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 2* <i>v</i> 2-2-2	7 <i>disp</i> <i>dw</i> 6
IV	<i>d</i> 2*	<i>pl</i> 2 <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 4 <i>rl</i> 2 <i>v</i> 2-1-2	8 <i>disp</i> <i>dw</i> 6
<b><i>Mallinella zebra</i> (Thorell) n.comb. (♂)</b>				
I	<i>pl</i> 2* <i>d</i> 4* <i>rl</i> 1	<i>pl</i> 1	11 <i>disp</i>	12 <i>disp</i>
II	<i>pl</i> 2* <i>d</i> 4* <i>rl</i> 2*	<i>pl</i> 1	11 <i>disp</i>	9 <i>disp</i>
III	<i>pl</i> 3* <i>d</i> 4* <i>rl</i> 1	<i>pl</i> 1 <i>rl</i> 1	12 <i>disp</i>	17 <i>disp</i>
IV	<i>pl</i> 3* <i>d</i> 4* <i>rl</i> 1	<i>pl</i> 1 <i>rl</i> 1	14 <i>disp</i>	19 <i>disp</i>
<b><i>Mallinella zebra</i> (Thorell) n.comb. (♀)</b>				
I	<i>pl</i> 1 <i>d</i> 3*	—	<i>pl</i> 2* <i>v</i> 2-1-2-2	<i>v</i> 2-2-2
II	<i>pl</i> 1 <i>d</i> 3*	<i>pl</i> 1	<i>pl</i> 2* <i>v</i> 2-2-2	<i>v</i> 2-2-2
III	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 1	<i>pl</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 2* <i>rl</i> 2* <i>v</i> 2-1-1-2	8 <i>disp</i> <i>dw</i> 5
IV	<i>pl</i> 2* <i>d</i> 4* <i>rl</i> 1	<i>pl</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 2* <i>rl</i> 2* <i>v</i> 2-1-1-2	10 <i>disp</i> <i>dw</i> 6
<b><i>Nostera leucosema</i> (Rainbow) n.comb.</b>				
I	<i>pl</i> 1 <i>d</i> 2*	—	<i>v</i> 2-2	<i>v</i> 2-2-2
II	<i>pl</i> 1 <i>d</i> 2*	—	<i>pl</i> 2* <i>v</i> 1-2-2	<i>v</i> 1-1-2
III	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 1	<i>pl</i> 1 <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 2* <i>rl</i> 2* <i>v</i> 2-2-2	12 <i>disp</i>
IV	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 1	<i>pl</i> 1 <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 2* <i>rl</i> 2* <i>v</i> 2-2-2	12 <i>disp</i>
<b><i>Nostera nadgee</i> n.sp. (♂)</b>				
I	<i>pl</i> 1 <i>d</i> 2*	—	<i>v</i> 2-2-2	<i>v</i> 2-2-3
II	<i>pl</i> 1 <i>d</i> 2*	—	<i>pl</i> 2* <i>v</i> 1-2-2	<i>v</i> 2-2-3
III	<i>pl</i> 1 <i>d</i> 3* <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 2* <i>v</i> 2-2-3	10 <i>disp</i> <i>dw</i> 6
IV	<i>d</i> 3*	<i>pl</i> 2* <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 2* <i>v</i> 2-2-2	10 <i>disp</i> <i>dw</i> 6
<b><i>Nostera nadgee</i> n.sp. (Transit Hill ♀)</b>				
I	<i>d</i> 1	—	—	<i>v</i> 1-2-2
II	<i>d</i> 1	—	—	<i>v</i> 2
III	—	<i>pl</i> 2* <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 2* <i>v</i> 1-2-1	8 <i>disp</i> <i>dw</i> 6
IV	<i>d</i> 1	<i>pl</i> 2* <i>d</i> 1 <i>rl</i> 1	<i>pl</i> 2* <i>d</i> 3* <i>rl</i> 2* <i>v</i> 1-2-2	10 <i>disp</i> <i>dw</i> 6

## The Taxonomy of Amphipoda (Crustacea) from Australian Fresh Waters: Part 2

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**ABSTRACT.** Taxonomic information on freshwater species from Western Australia, Queensland and South Australia is presented. The following new crangonyctoid taxa are established: *Austrogammarus telsosetosus*, *Toulrabia*, new genus, with *T. willsi*, *Uroctena whadjukia*, and *Chillagoe*, new genus, with *C. thea*; the following species is reviewed: *U. setosa*; the following new genera, apparently melitoid, are established: *Brachina*, new genus, with *B. invasa*, and *Nedsia*, new genus, with *N. douglasi*.

BARNARD, J.L. & W.D. WILLIAMS, 1995. The taxonomy of Amphipoda (Crustacea) from Australian fresh waters: part 2. Records of the Australian Museum 47(2): 161–201.

This report is the second of a planned series documenting our investigations of the taxonomy of Australian freshwater Amphipoda. Our first report laid the foundation for our studies in that, for the most part, it redescribed all known Australian crangonyctoid taxa and discussed the higher taxonomic category into which we placed them. The present report is mostly concerned with the description of new crangonyctoid taxa (but also adds to our knowledge of one known crangonyctoid, *Uroctena setosa* Nicholls, and describes two new non-crangonyctoid taxa).

For the present, we regard the non-crangonyctoid taxa we describe as part of the melitoid (hadzioid) complex, that is, as taxa of essentially marine derivation. Whatever their derivation, their description clearly emphasises the points made in our first report concerning the rich diversity of Australian freshwater

amphipods. It also indicates the range of sources from which this diversity derives. Given the relative dearth of taxonomic studies on Australian freshwater amphipods to date, particularly with regard to subterranean taxa, the discovery of further non-crangonyctoid taxa would not be surprising. Even so, crangonyctoids remain the dominant type in Australian fresh waters, outside those found in lowlands where ceinids (*Austrochiltonia*) dominate.

A comprehensive discussion of the crangonyctoid concept was given in our first report. In that discussion, we were generally critical of the concept as a whole but chose to support it as a useful working hypothesis or "enabling mechanism" promoting our studies until the time when knowledge of Australian freshwater amphipods was further advanced. The present paper follows the same principles. Thus, for present purposes, crangonyctoid amphipods are considered to possess a



combination of at least the following characteristics: 1, calceoli (when present) are of linear form (not cup-shaped); 2, the accessory flagellum of antenna 1 is 2+ articulate; 3, the outer ramus of uropod 3 is usually 2-articulate, but if not the uropod is variramous or parviramous; 4, coxae 5–7 are smaller than coxa 4; 5, basofacial spines on the peduncle of uropod 1 are absent; 6, inner lobes of lower lip are indistinct; 7, the palp of maxilla 1 is 2-articulate; 8, setae other than E-setae are present on the mandibular palp; 9, gnathopod 1 is not dominant.

The present studies suggest no major comment on these criteria and until our studies on Tasmanian and Victorian crangonyctoids are complete, any reconsideration of the crangonyctoid concept is clearly premature.

The melitoid (hadzioid) complex is equally difficult to demarcate and it too needs reconsideration. For the present, however, we simply regard the melitoids as distinguishable from the crangonyctoids by, *inter alia*, their lack of linear calceoli, absence of sternal gills and the presence of a basofacial spine on the peduncle of the first uropod. The feature of melitoids that we regard as critical is the form of the first gnathopod, i.e. gnathopod small, hand almost rectangular with a short transverse palm having simple (non-symmetrically bifid) spines and with an elongate wrist.

### Methods of Dissection and Description

Our methods of dissection and description are essentially those used before (Williams & Barnard, 1988). They need no repetition here. To expedite the use of the present work, however, it will be helpful to note the following abbreviations.

Setae in text formulae have the following abbreviations: E, large seta; e, small seta; S, large spine; s, small spine. Spines are considered to be inflexible setae.

A key to the abbreviations used in Figs 1–26 is as follows: A—antenna; Abd—abdomen; acc—accessory; C—coxa; d—dorsal; dact—dactylus; E—epimeron; fl—flake; flag—flagellum; g—gill; G—gnathopod; Hd—head; i—inner; juv—juvenile; l—left; lac—lacinia mobilis; LL—lower lip; MD—mandible; med—medial; mol—molar; MP—maxilliped; MX—maxilla; o—outer; O—oostegite; opp—opposite; p—palp; P—pereopod; PC—prebuccal complex; pl—plate; Pp—pleopod; r—right; sp—spine; sq—square view; sr—setae removed (sometimes marked by sockets); st—sternal gill; T—telson; U—uropod; UL—upper lip; UR—urosoma; 1, 2, 3... 7—first, second, third... seventh article, segment, somite or epimeron (as appropriate). These abbreviations are the same as those used previously by us.

## Crangonyctoidea

### Paramelitidae Bousfield

#### *Austrogammarus* Barnard & Karaman, 1984

*Austrogammarus* Barnard & Karaman, 1984: 60–61.

**Type species.** *Gammarus australis* Sayce, 1901, by original designation.

For the generic diagnoses, additional description, characters of interspecific value and sexual attributes see Williams & Barnard (1988: 16–17).

**Relationships.** *Austrogammarus* is regarded as the basic (most primitive) genus of Australian paramelitids.

**Composition.** This genus now includes seven species: *A. australis* (Sayce), *A. smithi* Williams & Barnard, *A. haasei* (Sayce), *A. saycei* Williams & Barnard, *A. spinatus* Williams & Barnard, *A. multispinatus* Williams & Barnard and *A. telsosetosus* n.sp. Keys to the first six of these species, based upon the most prominent specific differences, were given by Williams & Barnard (1988: 16–17). In these keys, *A. telsosetosus* keys to *A. multispinatus*. These two species differ only slightly from each other (see remarks under Relationships below).

#### *Austrogammarus telsosetosus* n.sp.

Figs 1–4

**Etymology.** Named for the basalwards extension of setae on the telson.

**Type locality.** Creek flowing into Lake Bonney, South Australia, beyond wood plant effluent outflow.

**Material examined.** HOLOTYPE (Australian Museum, P44058), female "q" 9.76 mm, in type series collected 21 November 1977, P. & D. Suter collectors, sample number 21: 280, 000 329 390". ALLOTYPE (Australian Museum, P44059) same sample, male "s" 7.42 mm. Other measured specimens, female "r" (P44060) 9.00 mm and male "t" (P44061) 7.70 mm. Five other specimens (P44062) in same sample. Tributary of Eight Mile Creek, South Australia, 22 November 1977, P. & D. Suter collectors, sample number 969 "1: 50, 000 824 900," juvenile "w" (P44063) 4.95 mm, female "v" 10.70 mm and 5 other specimens. Cress Creek, at Port MacDonnell, South Australia, 22 November 1977, P. & D. Suter collectors, sample number 971, male "u" (P44064) 5.91 mm. Other material: Eight Mile Creek, South Australia, January 1980, Keith F. Walker collector, 9 specimens (P44065).

**Diagnosis.** Flagellum of antenna 2 poorly setose and bearing calceoli in male. Coxae 1–4 weakly to not setose ventrally, coxa 4 lacking ventral setae, only with posteroventral setae and several anteroventral setae, coxae 1–3 with several posterior spines. Coxa 4 with

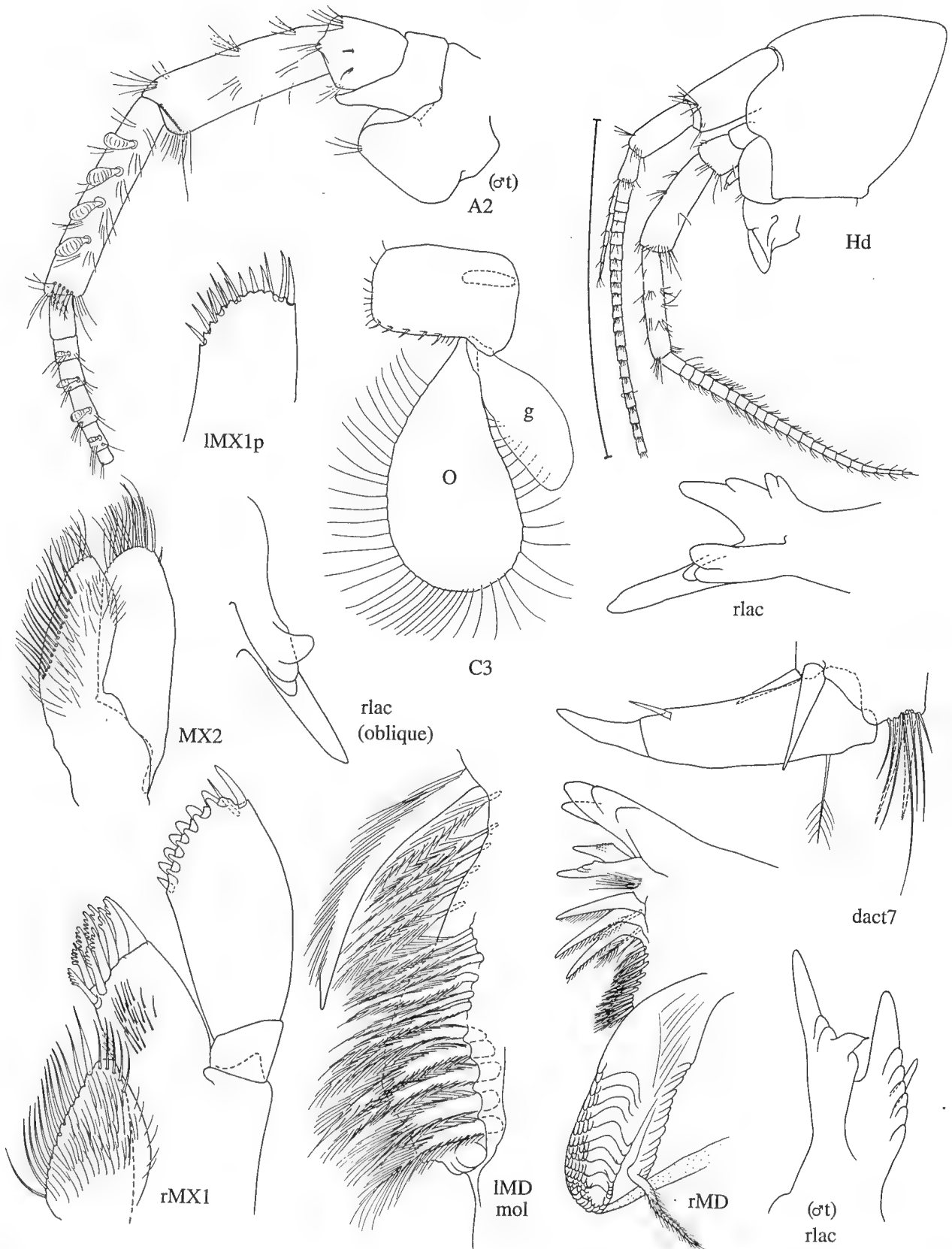


Fig. 1. *Austrogammarus telsosetosus* n.sp., holotype, female "q" 9.76 mm (all drawings except those indicated); male "t" 7.70 mm.

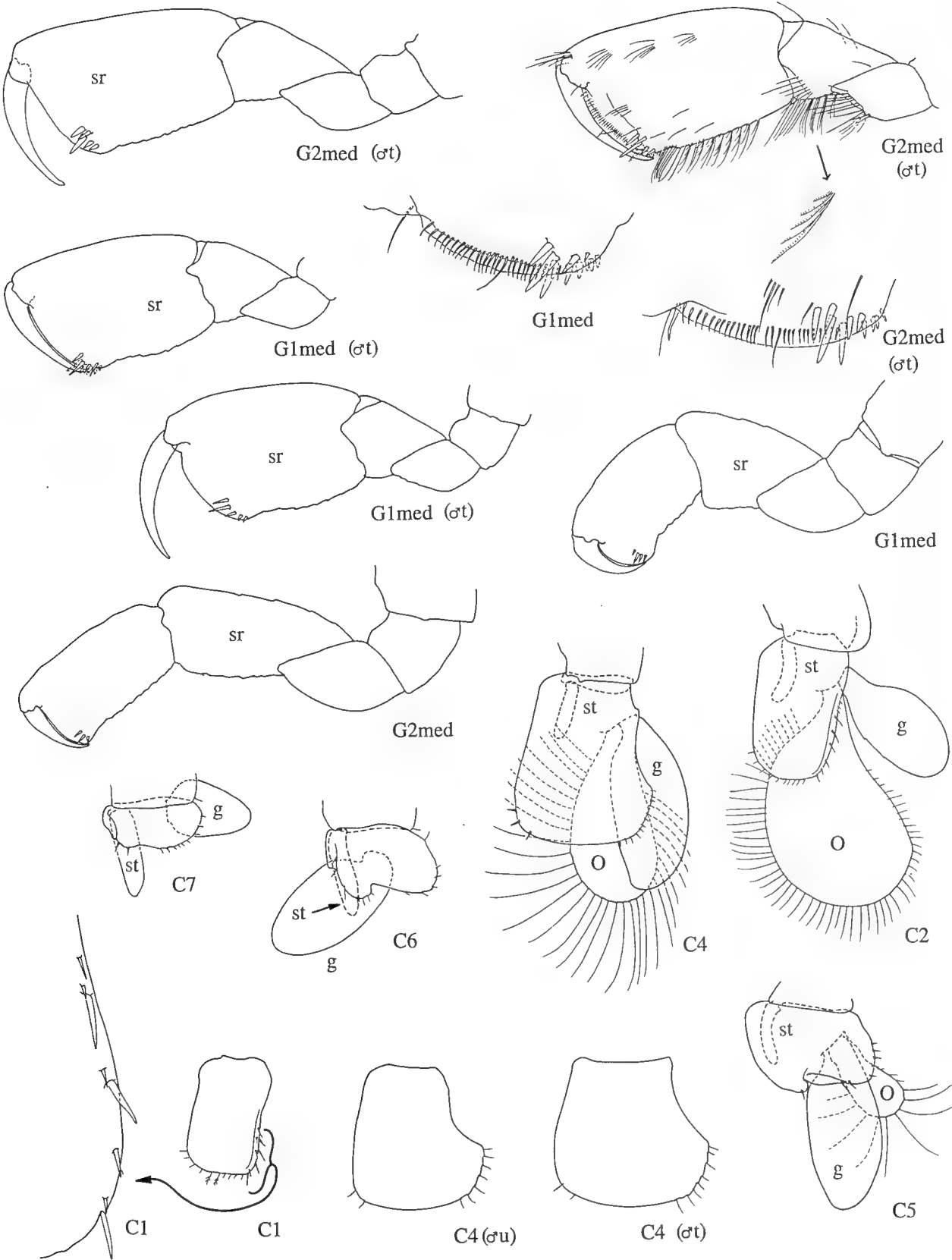


Fig. 2. *Austrogammarus telsosetosus* n.sp., holotype, female "q" 9.76 mm (all drawings except those indicated); male "t" 7.70 mm; male "u" 5.91 mm.

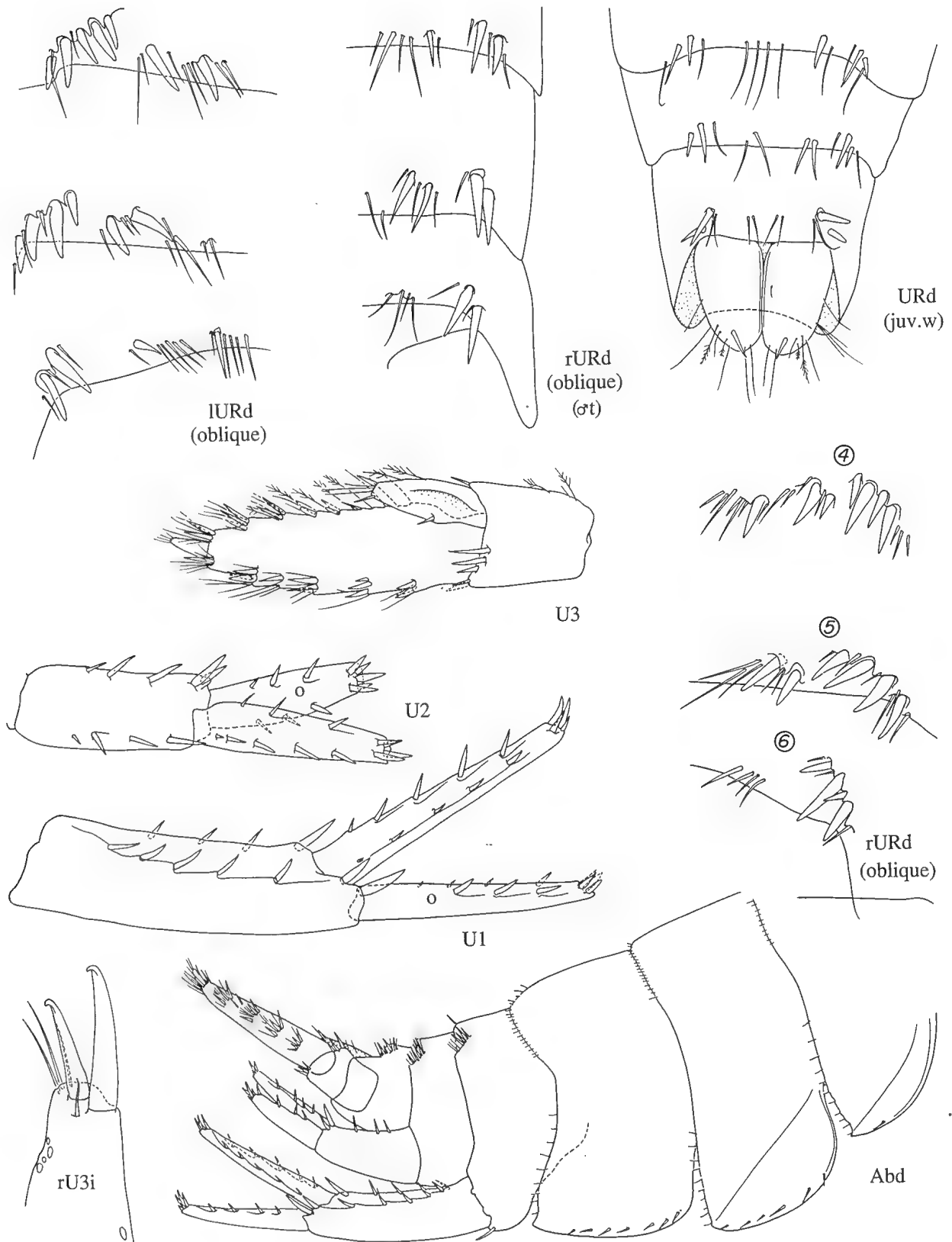


Fig. 3. *Austrogammarus telsosetosus* n.sp., holotype, female "q" 9.76 mm (all drawings except those indicated); male "t" 7.70 mm; juvenile "w" 4.95 mm.

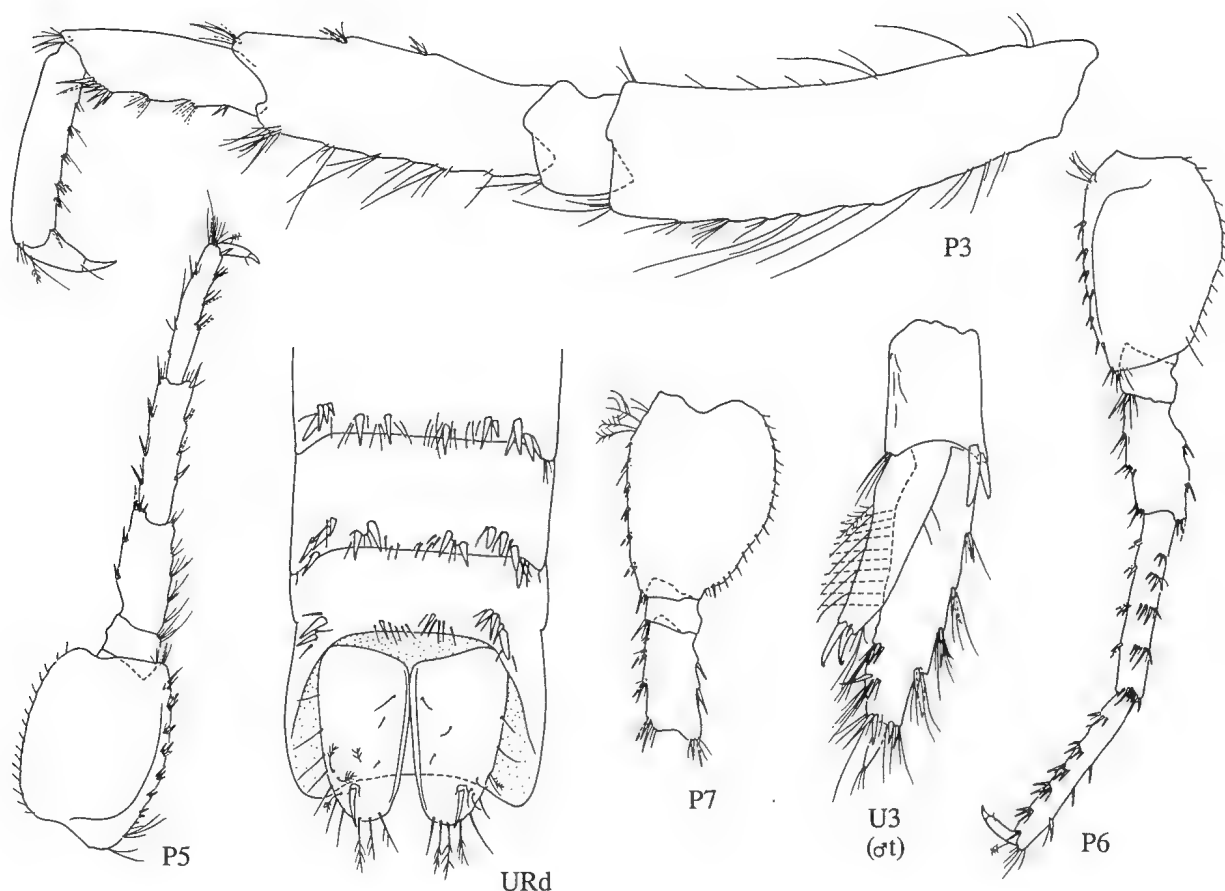


Fig. 4. *Austrogammarus telsosetosus* n.sp., holotype, female "q" 9.76 mm (all drawings except those indicated); male "t" 7.70 mm.

posteroventral lobe unusually weak. Gnathopods dimorphic between the sexes, palmar corners in male not bent outward, with 10 spines. Posterior spines on article 6 of pereopods 3–4 in single sets, without group of setae placed between spine sets 1 and 2, formula thus 2-2-3-2-2-1 (all spines) and 2-4-3-4-3; lateral spine formulae on article 5 of pereopods 3 and 4 = 3-1-2-1 and 4-4-4-1; article 2 of pereopods 5–7 with short setae; setae of articles 4–6 of pereopods 5–7 short and of low density; article 4 of only pereopod 7 short. Epimeron 1 without anteroventral setae. Urosomal setation dorsally short and stiff; pleonites 4–5 with 4+ dorsolateral spines on each side, with one or two additional dorsomedial sets of 1–2 spines, pleonite 6 with 2–4 spines on each side, formulae from medial to lateral on one side only, pleonite 4 = 1-2-4 or 1-1-5, pleonite 5 = 0-2-4, pleonite 6 = 0-2 or 0-4, often with incipiently thickened small spinules in middle of segment; none of uropods 1–2 with setae on peduncles and inner rami, apicolateral corner of peduncle on uropod 1 with 2 spines only, on uropod 2 with 2 spines only, medial spines on peduncle of uropod 1 (distal to proximal = 1-1-1-1), setae in same sets = 0, on uropod 2 = 1-1-1-1 and 0; uropod 3 strongly setose, inner ramus reaching to about M.33 in female and M.60 in male on outer ramus, with one subapical

spine in female only, apex with many setae and 2 long hooked spines in male placed towards medial side, with 2 widely separated spines in female, medial margin with setae in tandem, lateral margin with setae in male, with spine in female; article 1 on outer ramus with spine sets laterally and medially mixed with setae arranged in clusters, article 2 small, with short apical setae. Telson fully cleft, lobes separable, spinose and setose, setae extending more basalwards than in *A. multispinatus*.

**Description of holotype (female "q").** *Body* (Figs 3, 4): pleon dorsally setose, setation dense and transverse on pleonites 1–3, setae very short and confined to margins of segments, pleonites 4–6 with spine-seta rows weakly ranked longitudinally but generally in transverse band; length, 9.76 mm.

*Head* (Fig. 1): eyes absent.

*First antenna* (Fig. 1): length 0.57 of body, 1.3 second antenna, flagellum much longer than peduncle, setae sparse; accessory flagellum 6–7 articulate, reaching past article 7 of primary flagellum. *Second antenna* (Fig. 1): length 0.40 body; peduncle as long as flagellum, articles 4 and 5 equal in length, articles 3, 4 and 5 with weak ventral setation; flagellum 21 articulate, setose ventrally, lacking calceoli.

*Left mandible*: setae of palp article 3 = 4, 2A, 3, 5B, many D, 2E; incisor 5-toothed, lacinia mobilis 4-toothed, 6 setose accessory blades; molar (Fig. 1) with short setose spines. *Right mandible* (Fig. 1): incisor 4-toothed; lacinia mobilis bifid, denticulate; accessory blades of 3 setose spines and vestigial fourth; molar with short plumose seta. *Left first maxilla* (Fig. 1): palp article 2 with 11 thin apical spines and 4 scarcely subterminal facial setae; inner plate with 13 widely spread medial setae. *Right first maxilla* (Fig. 1): palp article 2 with 8 thick apical spines articulated to segment and one articulate apicolateral spine. *Second maxilla* (Fig. 1): outer margin of outer plate with one short seta; inner margin of inner plate with strongly submarginal row of many setae.

*First gnathopod* (Fig. 2): coxal plate sparsely setose marginally, posterior margin with 4 (aberrantly 7) spines; carpus weakly elongate, unlobed; propodus rectangular, longer than wide, posterolateral angle ordinary, palm oblique, curved. *Second gnathopod* (Fig. 2): slightly longer and thinner than first gnathopod, carpus elongate; coxal plate with 6 posterior spines.

*Pereopods* (Figs 1, 2, 4): coxa 3 with 5 posterior spines, coxa 4 lacking setae below and lacking posterior spines, deeply emarginate, but posterior lobe not as long as in *A. multispinatus*; pereopods 3–4 not longer than gnathopod 2, pereopod 3 longer than 4, article 4 moderately setose posteriorly.

*Epimera* (Fig. 3): all epimera with small posteroventral tooth, each with short posterior setules, epimera 1, 2 and 3 with 1, 6 and 7 ventrofacial spines. Uropod lengths relative to uropod 1: uropod 2 = 0.60, 3 = 0.73. *Pleopods 1–3*: peduncular setae = successively: 9 apicolateral; 8 apicolateral, 6–4–2 lateral, 4 basomedial; 5 apicolateral, 4–6 basolateral, 4 basomedial; coupling hooks = 2, accessory spines = 2; articles of outer rami = 20–20–19, of inner rami = 17–17–16, setae of basal article for each ramus laterally to medially = 7–2–3–8, 5–3–2–7 and 4–1–1–7.

*First uropod* (Fig. 3): peduncle length  $1.2 \times$  length of rami. *Second uropod* (Fig. 3): peduncle 1.2 inner rami. *Third uropod* (Fig. 3): peduncle length 0.37 outer rami, about same length as urosomite 3; proximal article with 6 medial and 6 lateral transverse spine-setae; inner ramus length 0.33 of outer. *Telson* (Fig. 4): about as long as urosomite 3; fully cleft; apices strongly setose, dorsum of each lobe with one spine and numerous setae, several of these basal and basolateral setae extending to M.40.

**Description of other material.** Specimen "t" (Figs 1–4): male; length 7.70 mm; like female but article 5 of antenna 2 (Fig. 1) with 4 calceoli, basal articles past article 1 of flagellum each with calceolus (antennae of available males otherwise broken). Propodi of gnathopods (Fig. 2) expanded, carpi shortened, medial defining spines of palm 4, lateral 6. Coxa 4 (Fig. 2) more strongly produced but not as strongly as in *A. multispinatus*. Peduncle of uropod 3 (Fig. 4) with 3 apicolateral spines (only 2 showing in figure), with 6 ventral spines (not

shown); inner ramus reaching to M.60 on outer ramus, apex with 2 hooked spines, medial margin widely setose, article 1 of outer ramus with number of spine-setal ranks much reduced (but body length of male much shorter than in female), medial base more widely setose. Five lateral setae (or setal positions, one positions with 2 setae) on each side.

Specimen "r": female; 9.00 mm; spines on article 5 on pereopod 3 = 5–1–1, on pereopod 4 = 5–1–2–1–0 (last position bearing seta only); total spines on left article 2 of pereopod 3 (proximal to distal) = 2–2–2–2–2, on right pereopod 3 = 1–2–2–1–2, on left pereopod 4 = 2–2–3–3–2.

Specimen "v": female, 10.70 mm, spines on one side of pleonites 4–6 = 5–4–3.

Specimen "u": male, 5.91 mm, coxa 4 illustrated for varietal shape.

Specimen "w": juvenile, 4.95 mm, urosome (Fig. 3) spine counts on one side of urosomites 4–6 = 2–2–2 or 3–4–2 (variable).

**Illustrations.** The lower lip and maxilliped are like *A. australis* but the maxilliped is even more setose and spinose.

**Relationship.** Differing only slightly from *A. multispinatus* and perhaps a subspecies of it. The two taxa are separated by a distance of 800 km. *Austrogammarus telsosetosus* differs from *A. multispinatus* in the slightly larger count of dorsal spines on the pleonites in adults, the basalwards extension of setation on the telson and the slightly shorter lobe on coxa 4.

**Distribution.** South-eastern South Australia just west of border with Victoria, streams (blind, therefore possibly hypogean, living as epigeans only in vicinity of emergent springs).

### *Toulrabia* n.gen.

**Etymology.** Named for the type locality.

**Type species.** *Toulrabia willsi* n.sp.

**Diagnosis.** Pleonites with several dorsal setae. Rostrum weak, lateral cephalic lobes strongly projecting and strong antennal sinus present. Eyes absent.

Antenna 1 elongate, longer than antenna 2, ratio of peduncular articles about 40:28:15, accessory flagellum 2-articulate. Antenna 2 very short, flagellum much shorter than peduncle, calceoli absent.

Ratio of mandibular palp articles about 6:20:15, article 2 poorly setose, article 3 weakly falcate, setae = CDE. Labium lacking inner lobes. Maxillae barely setose medially, inner plate of maxilla 1 subrectangular, with 2 apicomedial setae, outer plate with 9 spines, palps asymmetric, right one with thin apical spines, left one with thick apical cusps fused to segment. Inner plate of maxilla 2 lacking oblique row of setae on face, lacking medial setae.

Coxae 1–4 of medium length, longer than broad, coxae 1–4 lacking posterior spines, coxa 1 not expanded below, coxa 4 weakly excavate posteriorly, coxa 5 much shorter than 4. Gnathopods 1–2 small (in female, male unknown), carpi of medium length, nearly as long as propodi, weakly lobate, meri lacking hyaline lobe, palms weakly (1) to strongly (2) oblique, lacking rugosities, spines not symmetrically bifid, rather with small subapical trigger-like extensions; spines at corner of palm = 1 and 2; long thin setae along palm dense and simple.

Pereopods 5–7 moderately elongate, pereopod 6 longer than pereopod 7, article 2 moderately expanded, elongate-pyriform, posteroventrally lobate on pereopods 5–6, scarcely so on pereopod 7; dactyls of pereopods 3–4 with 1 accessory spinule, of pereopods 5–7 with 3–5 spinules on inner edge besides ordinary setule attached to side of unguiform base.

Coxae 2–6 each with gill, gill 6 not reduced. Thoracic segments 6–7 with anterolateral sternal gills of sausage form, two pairs on sternite 6, one pair on sternite 7; medial gill of each pair on sternite 6 longest, gills of sternite 7 very small. Coxae 2–5 with oostegite, small but broad on coxa 5, very large and broad on coxae 2–4, longer than broad on coxae 2–3, about square on coxa 4.

Uropod 3 poorly extended, peduncle short, outer ramus 1-articulate, slightly longer than peduncle, inner ramus short and scale-like, generally reaching to M.40 on article 1 of outer ramus. Telson shorter than broad, cleft about 60 percent, lobes tumid laterally, with apical spination and setation, no basolateral armaments except for pair of lateral penicillate setules about M.60 on each side.

**Additional description.** Upper lip uniform, rounded and symmetrical below. Accessory blades (rakers) on mandibles very few (3–4), on right side with interraker plumose seta between each main raker; on right mandible few additional penicillate setae beyond rakers and riding onto base of molar, on left mandible instead with large basal molarial ragged seta besides regular apical molarial seta. Both plates of maxilla 2 with apical setae of medium length; inner plates of maxillae 1–2 and medial and lateral margins of maxilla 2 poorly covered with pubescence. Maxillipedal inner plate very long, with distal row of several plumose setae and 3 blunt naked spines (in groups of 2 and 1), and medial row of plumose setae; outer plate large, with distal row of few plumose setae continuous with medial row of blunt naked tooth-spines; palp articles 2–3 weakly setose laterally, article 2 well setose medially, article 3 lacking organised comb row of spines near base of dactyl, apex barely produced, not rugose. Dactyls of gnathopods with small recumbent inner tooth-spine, with stiff spinules or setules at inner nail articulation line and with additional spinule on inner dactylar margin. Gnathopod 1 without one rastellate seta of article 4 enlarged and scythe-like. Pereopods 3–4 especially short and thin relative to pereopods 5–7. Posterior spine sets on article 6 of pereopods 3–4 evenly spaced. Pleopods similar,

peduncles moderately setose; outer rami extending subequally; basomedial setae on inner rami of pleopods not bifid; retinacula 2, accessory retinacula present. Posteroventral tooth of epimera 1–3 absent, posterior margins smooth and sparsely setulose; some epimera with facial spines near ventral margin. Apicolateral corner of peduncles on uropods 1–2 with 2 and 3 spines (thus with 1–2 ventrally displaced spines), dorsal margins spinose, medial margin of uropod 1 spinose; rami of uropod 1 extending equally, outer ramus of uropod 2 scarcely shortened; uropod 1 lacking basofacial armaments; only inner rami of uropod 2 with 2 spine rows. Medial setae of outer ramus on uropod 3 absent; usually with subdistal peduncular seta(e). Ventrodistal spine on urosomite 1 at base of uropod 1 moderately developed.

**Sexual dimorphism.** Only female known.

**Relationship.** This genus closely resembles *Hurleya* but differs in the following ways: (1) it bears C setae on the mandibular palp; (2) it has a short article 1 on the mandibular palp; (3) it has feeble gnathopods in the female; (4) it has four (versus two) sternal gills on pereonite 6; and (5) it lacks article 2 on the outer ramus of uropod 3.

### *Toulrabia willsi* n.sp.

Figs 5–7

**Etymology.** Named for the explorer William John Wills, 1834–1861.

**Type locality.** Stream on Mount Toulrab, Stirling Ranges, Western Australia.

**Material examined.** HOLOTYPE (Western Australian Museum, WAM 15-19), female “a” 6.14 mm, in type series collected 22 December 1965 by D.H.D. Edward. Other material examined (PARATYPES), female “b” 5.64 mm. Six other female specimens in same sample.

**Diagnosis.** As in the genus.

**Description of holotype (female “a”).** *Body* (Fig. 5): urosome poorly armed dorsally; length, up to 6.14 mm.

*Head* (Fig. 5): rostrum obsolescent; eyes absent.

*First antenna* (Fig. 5): length 0.66 of body, 2.1 second antenna, flagellum longer than peduncle, peduncular article 1 longest, article 3 shortest, setae sparse, flagellum with 23 articles, no calceoli, no aesthetascs; accessory flagellum 2-articulate, articles of primary flagellum uniform, sparsely setulate. *Second antenna* (Fig. 5): length 0.33 body; peduncle longer than flagellum, article 4 longer than 5, articles 3, 4 and 5 with moderate ventral setation, article 3 without dorsomedial spines; flagellum 7-articulate, moderately setose ventrally, lacking calceoli.



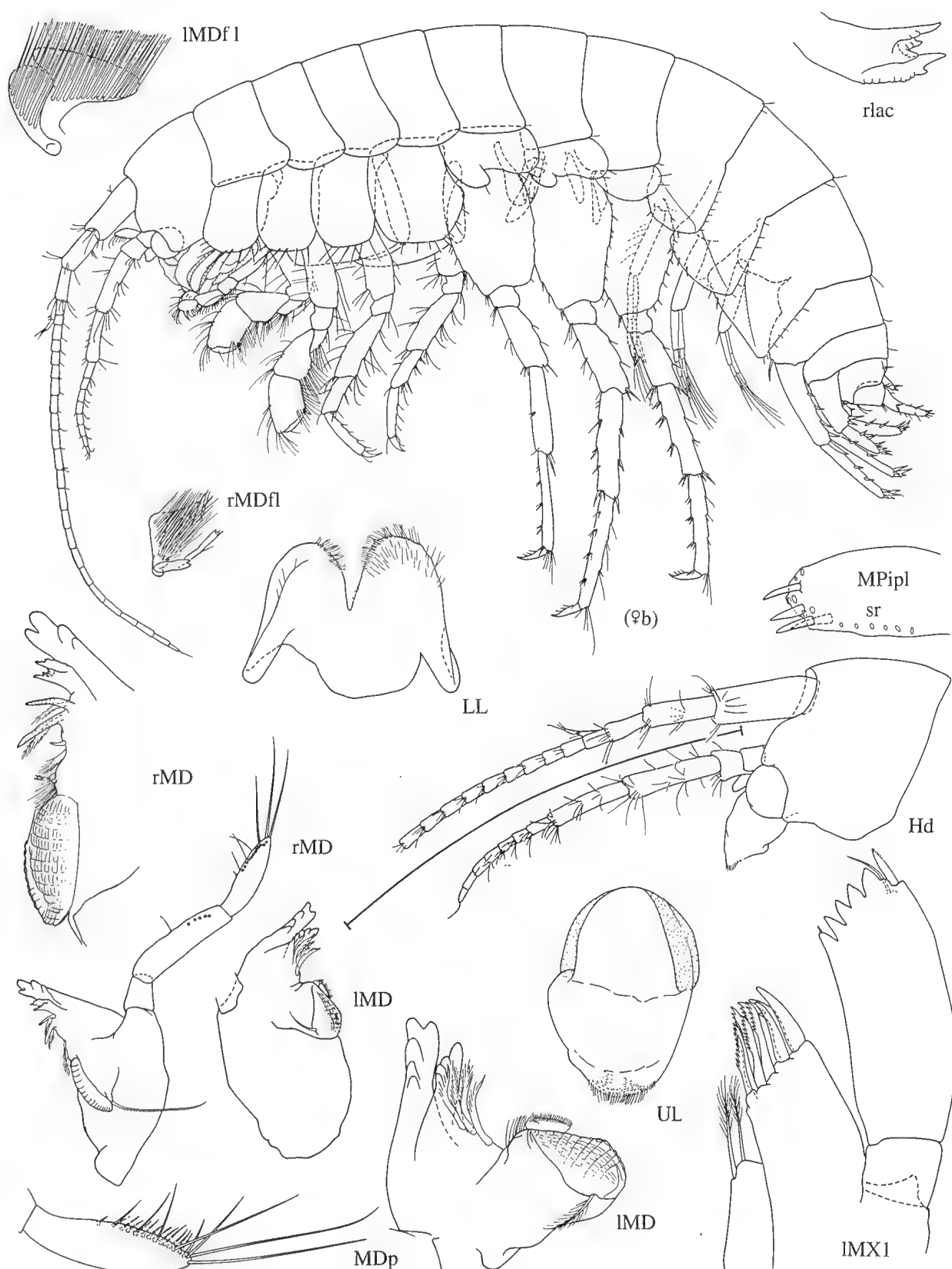


Fig. 5. *Toulrabia willsi* n.sp., holotype, female "a" 6.14 mm (all drawings except those indicated); female "b" 5.64 mm.

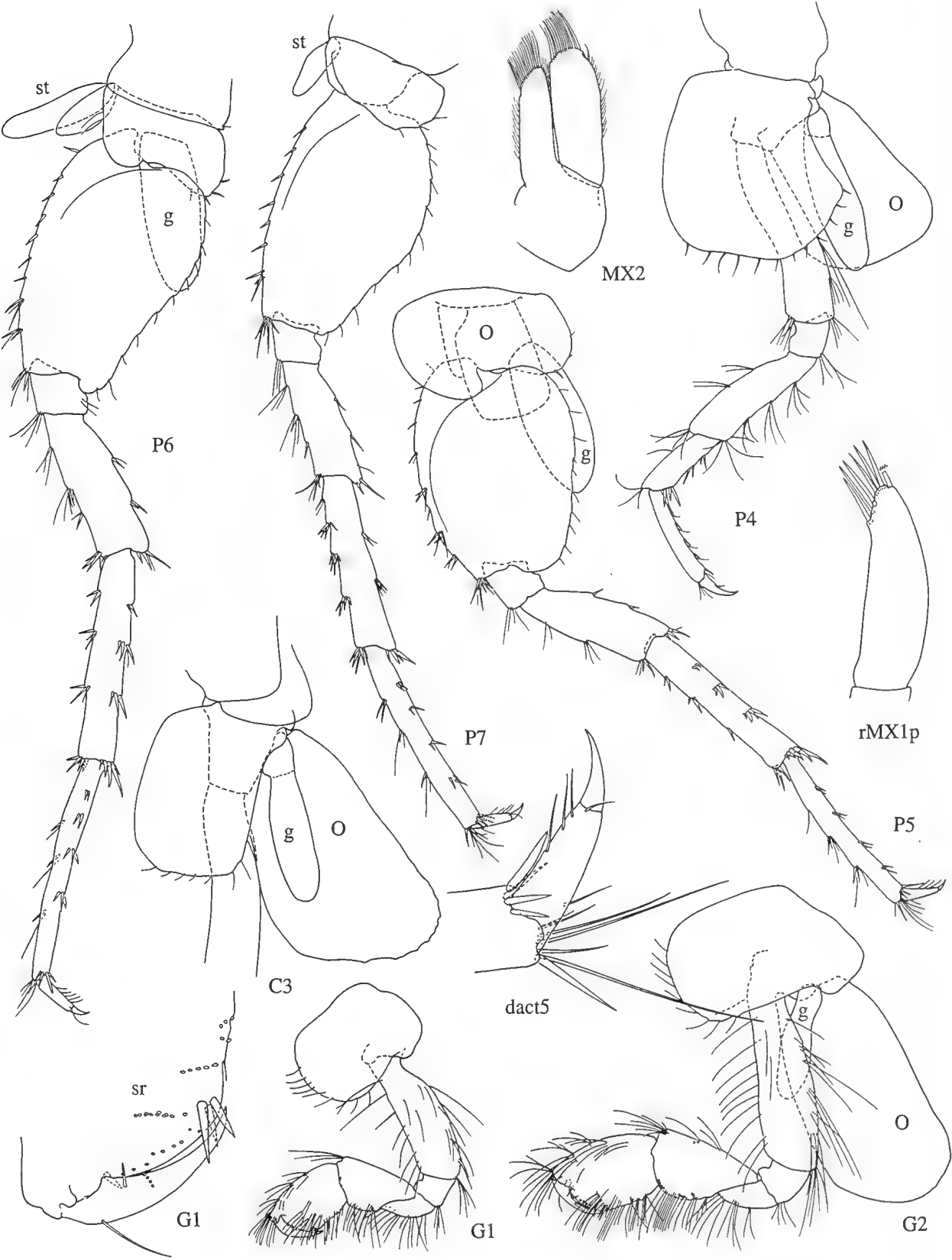


Fig. 6. *Toulrabia willsi* n.sp., holotype, female "a" 6.14 mm.

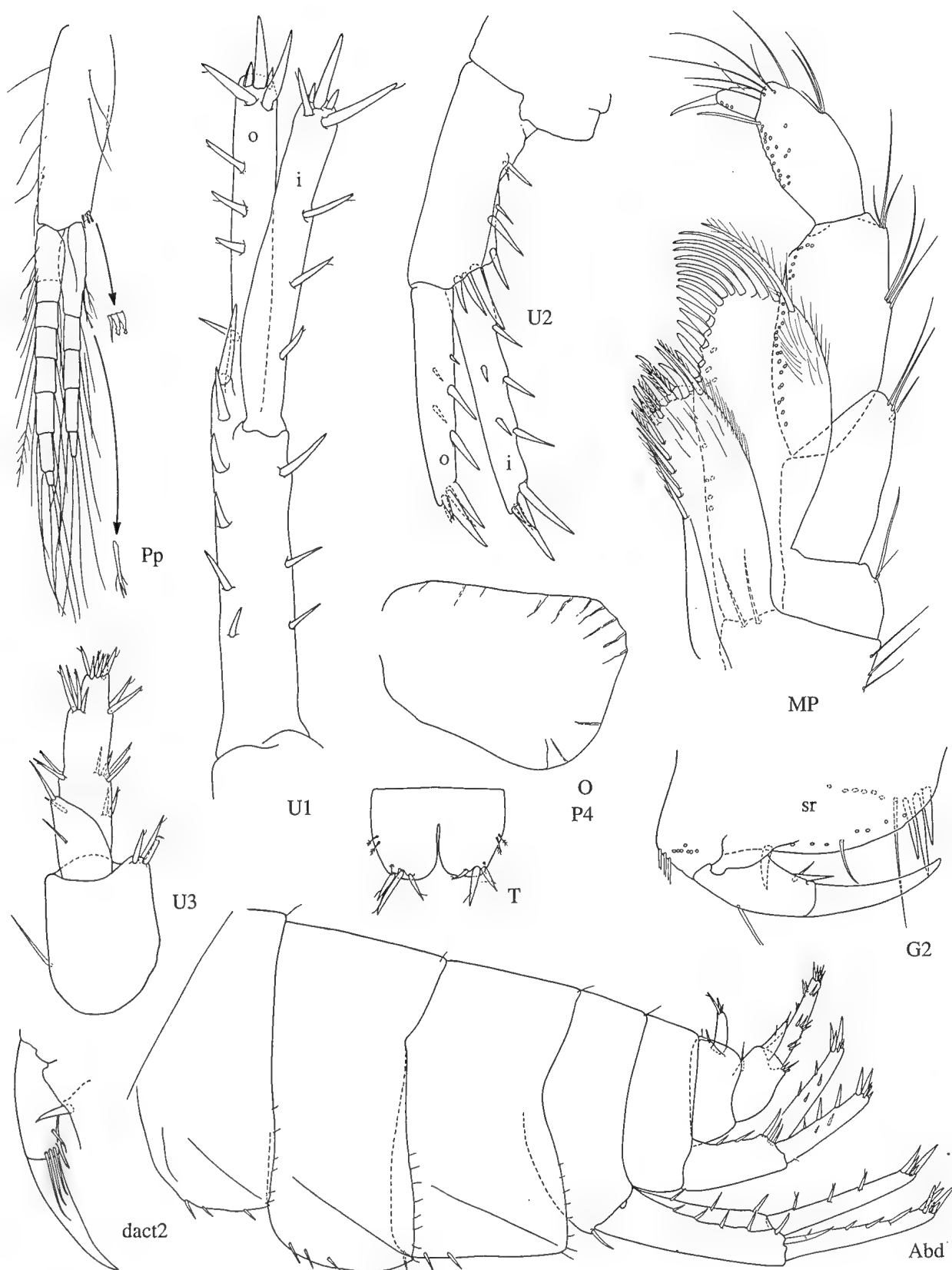


Fig. 7. *Toulrabia willsi* n.sp., holotype, female "a" 6.14 mm.

*Upper lip* (Fig. 5): apical margin evenly rounded but connection to epistome and epistome itself slightly asymmetrical. *Left mandible* (Fig. 5): palp article 3 shorter than 2, article 2 with 6 medial marginal setae, article 3 with 4C, 14D, 3E; incisor 5-toothed, lacinia mobilis 4-toothed, 4 setose accessory blades; molar bearing distal plumose seta, several penicillate hooked brushy basal setae, other pubescence, and pair of immensely setulate chisel spines. *Right mandible* (Fig. 5): incisor 4-toothed; lacinia mobilis bifid, very broad, each flake denticulate; accessory blades of 2 plumose spines. *Right first maxilla* (Fig. 6): palp article 2 with 7 thin apical spines, outer plate with 9 spines, most denticulate; inner plate with 2 apicomedial setae. *Left first maxilla* (Fig. 5): palp article 2 with 5 thick apical spines mostly fused to segment, one apicolateral thin spine and one subterminal apicolateral facial seta. *Second maxilla* (Fig. 6): outer plate outer apical margin with 1 small spinule, apicomedial margin of inner plate lacking setae. *Maxilliped* (Fig. 7): palp article 3 with ranks of thin setae on inner edge; inner plate (Fig. 5) with 1 ventrofacial spine.

*First gnathopod* (Fig. 6): coxal plate with short setae apically, without posteroventral spine; article 4 without posterior hump, carpus weakly lobate; propodus subrectangular, longer than wide, posterior edge widely setose, posterolateral angle rounded, with 1 medial and 2 lateral spines, no lateral spine elongate, palm slightly oblique, convex; dactylus reaching end of palm. *Second gnathopod* (Figs 6, 7): similar; palmar corner with 2 lateral and 1 medial spines, coxal plate similarly setose.

*Pereopods* (Figs 6, 7): coxa 3 with similar setae, coxa 4 emarginate, with similar setae; pereopods 3–4 slightly longer than gnathopod 2, pereopod 3 scarcely longer than 4, article 4 sparsely setose posteriorly, article 5 poorly spinose posteriorly, posterior spine formula = EE-EE-EEE, posterior margin of article 6 on pereopods 3–4 with spine formula of ES-ES-ES-ES-SS and EES-ES-ES-SS; pereopods 5–7 similar, each with 4 locking spines; coxae 5–7 bearing few setae on ventral margin of posterior lobes, article 2 weakly expanded and lobate posteroventrally, lobe obsolescent on pereopod 7, bearing thin medium to short posterior setae; dactyls of pereopods 3–7 with accessory spine formula of 1-1-3-5-4. Gills of coxae 2–6 sausage shaped, of pereopod 6 not reduced. Oostegites (Fig. 7) lacking setae except for tiny apicomarginal pits.

*Sternal (gills) processes*: segments 6–7 with sausage-shaped sternal gills in formula of (on one side) 2-1, gills attached to front of lateral edge of segment, pair of gills on sternite 6 arranged transversely, lateralmost gill shorter.

*Epimera* (Fig. 7): each epimeron posteroventrally quadrate, posterior margins scarcely convex, smooth and setulose, each epimeron with 3 ventral spines and lateral oblique ridge. *Pleon*: each dorsolateral posterior margin of pleonites 1–6 with following setal-spine formula (s=side, t=top): 1 = Es, 2 = Es, 3 = Es, 4 = Es, 5 = 0, 6 = EtSs; uropod 3 (Fig. 5) not extending beyond uropods 1 and 2 in entire animal, uropod lengths relative

to uropod 1: uropod 2 = 0.66, 3 = 0.50. *Pleopods* (for specimen "b"): retinacula 2 per pleopod, one accessory; peduncles each with 5+2, 6+2+2+2, and 4+2 setae, rami extending equally, outer with 8-7-6 articles, inner with 5-5-5 articles, setae on basal articles = 7-1-1-3, 5-1-1-2, 3-2-1-2, none bifid.

*First uropod* (Fig. 7): peduncle length 1.3 rami; outer margin with 1 apicodistal spine besides row of 5 dorsal spines, with 3 medial spines; rami of subequal length, both rami with 1 row of marginal spines. *Second uropod* (Fig. 7): peduncle about  $1.0 \times$  length of inner ramus, with 3 apicodorsal spines, 2 dorsolateral spines, medial margin with 3 spines, basalmost small; outer ramus subequal to inner, both with 2 rows of marginal spines in formula of 3-2, apices of rami on uropods 1–2 with 5 spines. *Third uropod* (Fig. 7): peduncle length 0.80 outer ramus, longer than urosomite 3, with subdistal seta besides apical cluster of 3 spines; outer ramus proximal article with several irregular spine ranks, article 2 absent; inner ramus length 0.40 of outer, with 1 apical spine. *Telson* (Fig. 7): broader than long, shorter than urosomite 3; cleft 60 percent of its length; apices each with 3 spines in facial notches, 1 apicolateral setule, each lobe with pair of penicillate setules dorsolaterally at M.60.

**Distribution.** Western Australia, Stirling Ranges.

### *Uroctena* Nicholls

*Uroctena* Nicholls, 1926: 106.

**Type species.** *Uroctena affinis* Nicholls, 1926, by original designation (not = *Neoniphargus westralis* Chilton, 1925).

For the generic diagnosis, additional description, characters of interspecific value, sexual attributes, and relationships, see Williams & Barnard (1988: 90–91).

**Speciation.** The new material at our disposal does not allow us to expand on our previous remarks concerning the extent and nature of speciation within the genus (Williams & Barnard, 1988: 90). Thus, we retain as valid the several species of *Uroctena* so far described despite the small differences between them. There is no doubt, however, that *Uroctena setosa* is very distinct from the group of *U. westralis* – *affinis* – *whadjukia* – *yellandi*.

**Composition.** With our description of a new species of *Uroctena*, the genus at present contains five species: *U. affinis* Nicholls, *U. westralis* (Chilton), *U. setosa* Nicholls, *U. yellandi* Nicholls and *U. whadjukia* n.sp. A new key to enable separation of these species is given below.

Key to the Species of *Uroctena*

1. Antennae 1–2 densely setose, setae long and drooping, telson cleft halfway, gnathopods of both sexes bearing long anterior setae on carpus and propodus, article 2 of male gnathopod 2 lacking stout spines ..... *U. setosa*
- Antennae 1–2 poorly setose, setae short and stiff, telson cleft 75+ percent, gnathopods of both sexes lacking long anterior setae on carpus and propodus, article 2 of male gnathopod 2 with stout spines ..... 2
2. Article 2 of male gnathopod 2 with stout anterior spines ..... 3
- Article 2 of male gnathopod 2 with thin anterior spines or setae ..... 4
3. Article 2 of male gnathopod 2 with 4 sets (3–4 each) of posterolateral spines ..... *U. affinis*
- Article 2 of male gnathopod 2 with 2 sets (2 each) of posterolateral spines ..... *U. whadjukia*
4. Article 2 of male gnathopod 2 with about 10–14 lateral spines, eyes absent ..... (and young of *U. affinis*) *U. westralis*
- Article 2 of male gnathopod 2 with about 6–8 lateral spines, eyes well developed but white ..... (and young of *U. affinis*) *U. yellandi*

*Uroctena whadjukia* n.sp.

Figs 8–13

**Etymology.** From the principal, original Aboriginal tribe of south-western Australia.

**Type locality.** Wungong System, Chandler Road, creek draining granite outcrop, stop 2.

**Material examined.** HOLOTYPE (Western Australian Museum, WAM 16-95), male “g” 7.1 mm, in type series collected 16.7.82 by C.M. Austin and B. Knott. ALLOTYPE (Western Australian Museum), female “h” 3.60 mm. Other material (PARATYPES) examined, juvenile “j” 1.17 mm, male “k” 7.19 mm. Ten other adults and ten other juveniles in same sample.

**Diagnosis.** Eyes not visible in preserved specimens. Setae of antennae 1–2 sparse and short; male antenna 2 weakly pediform, about 1.5 times as thick as antenna 1; propodus of male gnathopod 1 lacking stout posterior spines; article 2 of male gnathopod 2 with about 4 stout posterolateral facial spines in 2 sets and about 3–9 medium-stout anterior spines plus up to 8 setae in specimens with fewer than 5 spines; gnathopods of both sexes not setose as noted in description of *U. setosa*; telson cleft 70+ percent, each apex with 1 spine and 2–3 setae, each dorsum or lateral edge with 3 setae.

**Description of holotype (male “g”).** Body (Fig. 9): urosome moderately armed dorsally; length, 7.1 mm.

**Head** (Fig. 9): rostrum small; eyes in death absent.

**First antenna** (Figs 8, 9): length 0.6 of body, 1.45 second antenna, flagellum longer than peduncle, peduncular article 1 longest, article 3 shortest, setae sparse, medial face of article 1 with armament formula of SS-eSS-SS-e, flagellum with 24 articles, each article commencing at article 6 with tiny aesthetascs; accessory flagellum 5-articulate, reaching end of article 5 of primary flagellum, articles uniform, sparsely setulate. **Second antenna** (Figs 8, 9): length 0.40 body; peduncle longer than flagellum, article 4 longer than 5, articles 3, 4 and 5 with moderate ventral setation, article 3 with 3 dorsomedial spines; flagellum 9-articulate, well setose ventrally, lacking calceoli.

**Upper lip:** apical margin evenly rounded but connection to epistome and epistome itself slightly asymmetrical. **Left mandible** (Figs 8, 11): palp article 3 shorter than 2, article 2 with 9 medial marginal setae, article 3 with 2A, 2B, 3C, 2 D, 6E; incisor 5-toothed, lacinia mobilis 4-toothed, 6 setose accessory blades; molar bearing plumose seta, several penicillate hooked brushy basal setae, other pubescence, and one chisel spine. **Right mandible** (Figs 8, 9): incisor 4-toothed; lacinia mobilis not bifid, very broad, partly divided into 2 flakes, denticulate; accessory blades of 2 plumose spines, setae of palp article 3 with 2A, 2B, 2C, 6D, 5E. **Left first maxilla** (Fig. 9): palp article 2 with 6 thin

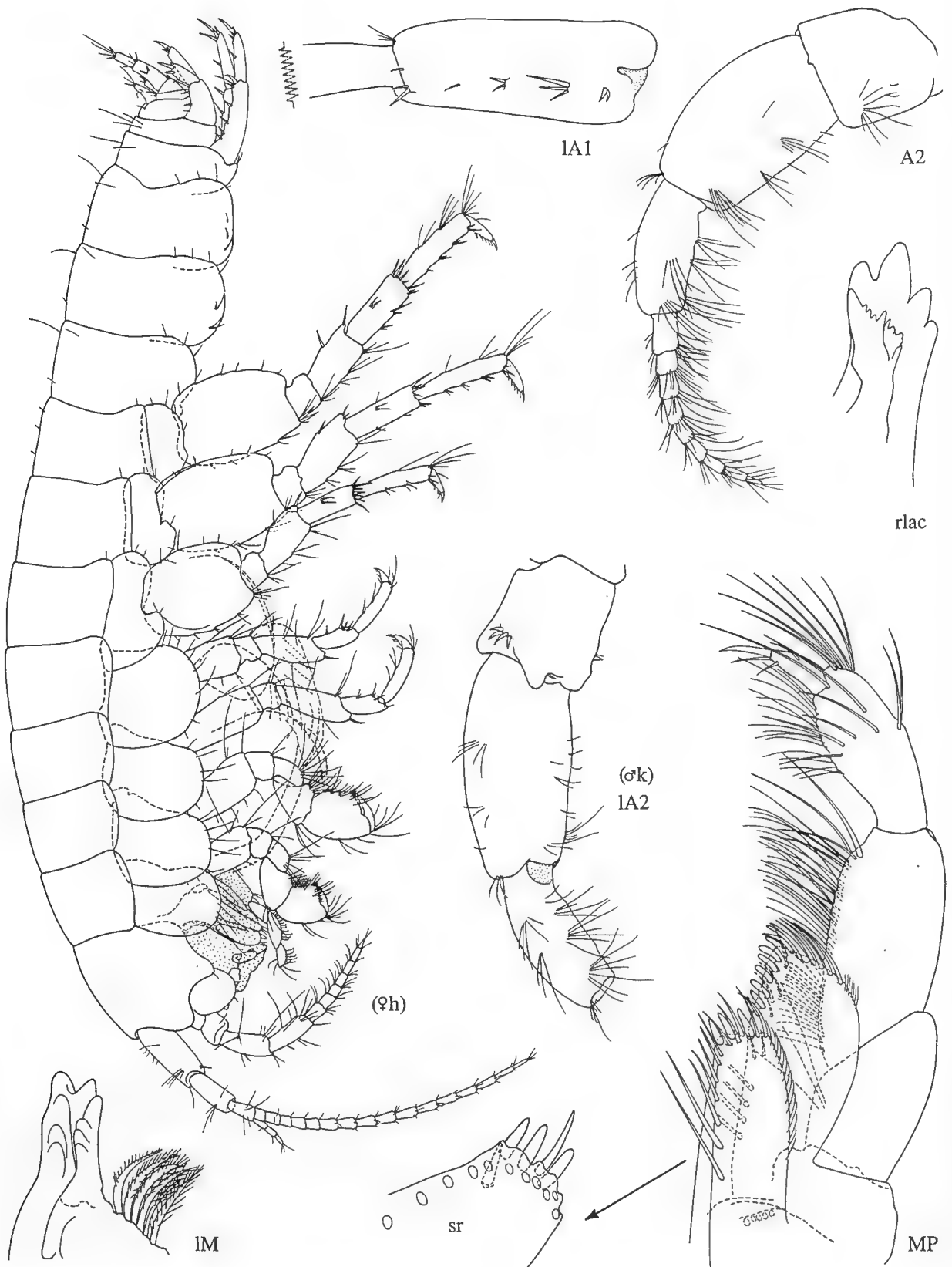


Fig. 8. *Uroctena whadjukia* n.sp., holotype, male "g" 7.09 mm (all drawings except those indicated); female "h" 3.60 mm; male "k" 7.19 mm.

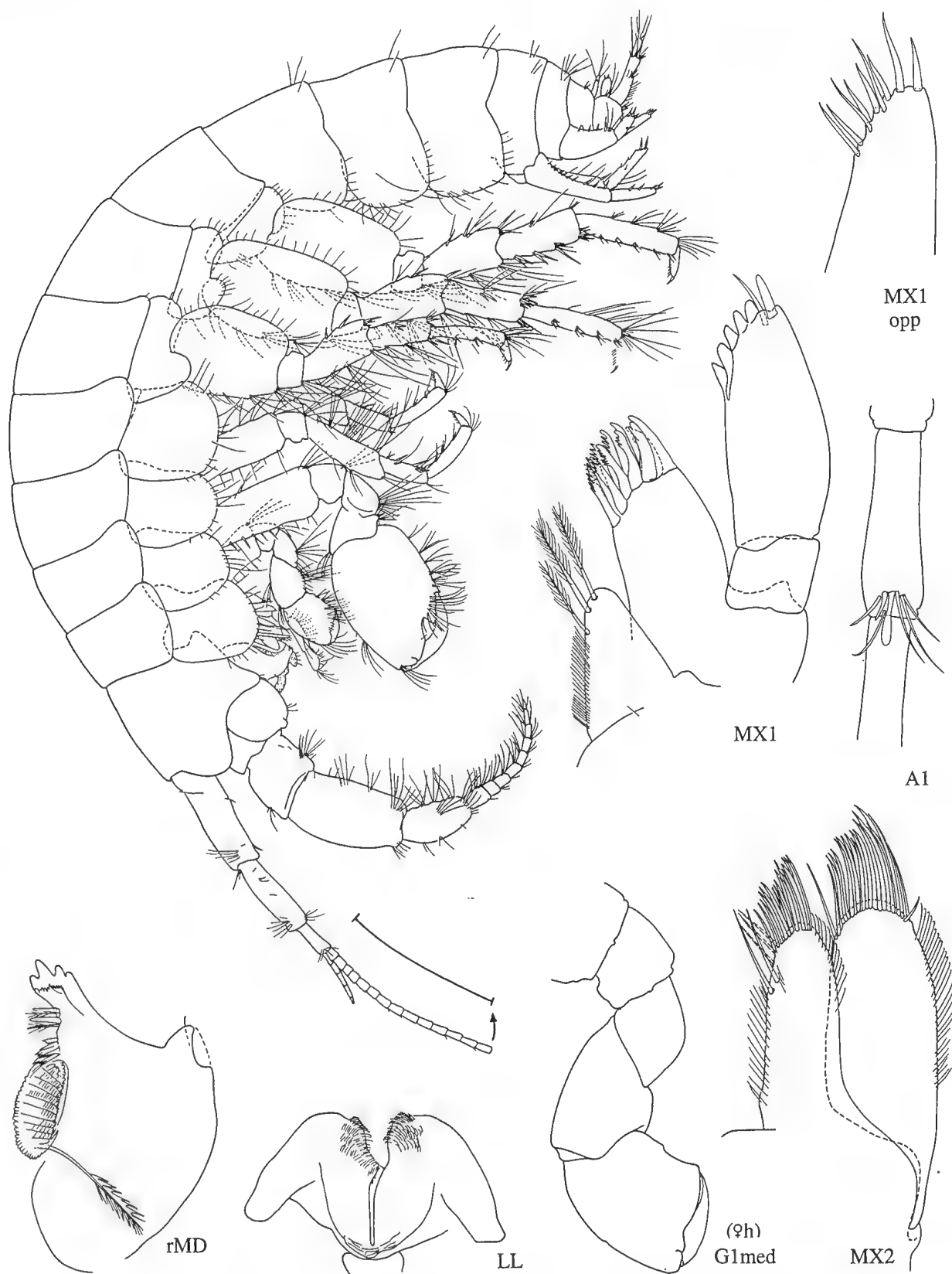


Fig. 9. *Uroctena whadjukia* n.sp., holotype, male "g" 7.09 mm (all drawings except those indicated); female "h" 3.60 mm.



apical spines and 3 barely subterminal facial setae, outer plate with 11 spines, most denticulate; inner plate with 3 apicomedial setae. *Right first maxilla* (Fig. 9): palp article 2 with 5 thick apical spines partly articulated to segment, one apicolateral thin seta. *Second maxilla* (Fig. 9): outer plate outer apical margin with 1 small spinule, apicomedial margin of inner plate with 2 weakly submarginal thick setae. *Maxilliped* (Fig. 8): palp article 3 with ranks of thin setae on inner edge, apical part with rank of 5 thicker setae, apex not strongly produced, not rugose; inner plate with 3 thick spines and several plumose setae apically, long medial row of plumose setae, and 1 ventrofacial spine.

*First gnathopod* (Figs 10, 11): coxal plate with long and short setae apically, with 1 posteroventral spine; article 4 without posterior hump; carpus well developed and longer than in *U. westralis*, narrow and not lobate; propodus subrectangular, longer than wide, posterolateral angle rounded, posterior edge with 3 acclivities and 3 sets of setae, with 1 medial and 3 lateral spines, no lateral spine elongate, palm slightly oblique, convex; dactylus reaching end of palm. *Second gnathopod* (Fig. 10): enlarged; article 2 with 3 medium anterior spines, posterolateral face with 4 spines in 2 sets, article 5 short and lobate, article 6 hugely ovato-rectangular, palm oblique, sculptured, palmar corner with 1 lateral and 1 medial spines, posterior margin near corner without spines; dactyl strongly curved, fitting palm; coxal plate well setose, with one posteroventral spine.

*Pereopods* (Figs 9–12): coxa 3 with long setae and one posteroventral spine, coxa 4 barely emarginate, with 4 anteroventral, 11 posterior setae and 2 posteroventral spines; pereopods 3–4 not longer than gnathopod 2, pereopod 3 scarcely longer than 4, article 4 well setose posteriorly, article 5 poorly setose posteriorly, posterior spine formula = eS-ESS-4S and EE-SS4S; posterior margin of article 6 on pereopods 3–4 with spine formula of ES-ES-ES-SS and ES-ES-ESS-SS; pereopods 5–7 similar, each with 3 locking spines and locking seta; coxae 5–7 bearing spines or setae on ventral margin of both lobes, article 2 expanded and lobate posteroventrally, bearing thin medium to long posterior setae; dactyls of pereopods 3–7 with spine formula of 4-4-4-6-(6), pereopod 7 internal formula = 1-1-2-2, thus spines doubled only on pereopod 7. Gills of coxae 2–6 sausage shaped, of pereopod 6 not reduced.

*Sternal (gills) processes* (Fig. 12): segments 2–7 with sausage-shaped sternal gills in formula of 1-1-1-2-2-2, gills on segments 2–6 central, on segment 7 attached to front of lateral edge of segment.

*Epimera* (Figs 9, 13): each epimeron posteroventrally rounded, posterior margins convex, notched and setose, setae long, epimeron 1 with 1 ventral seta, epimera 2–3 with setal formula of 1-2-2-2 and 1-3-2-1-1. *Pleon* (Figs 9, 13): each dorsolateral posterior margin of pleonites 1–6 with following setal formula (s=side, t=top): 1 = st; 2 = st; 3 = st; 4 = 2s, t; 5 = 2s, 3t; 6 = 2t; uropod 3 strongly extending beyond uropods 1 and 2 in entire animal, uropod lengths relative to uropod 1: uropod 2 = 0.75, 3 = 0.80. *Pleopods* (Fig. 12):

retinacula 2 per pleopod, no accessories; peduncles each with 19–19–30 setae, rami extending equally, outer with 13–15, 11, 10 articles; inner with 10–11, 9, 9 articles; setae on basal articles = 4-1-1-3, 4-2-1-3, 2-11-2, none bifid, variable on pleopod 1 on right and left members (formula averaged).

*First uropod* (Fig. 13): peduncle length 1.5 rami; outer margin with 1 apicodistal spine besides row of 10 dorsal spines and one seta between spines 8 and 9, with 1 apical spine medially and row of 4 setae; rami of subequal length, both rami with 2 rows of marginal spines or setae in formula of SS-SS and E-SS, outer ramus with 4 apical and inner ramus with 5 apical spines. *Second uropod* (Fig. 13): peduncle about 1.5 length of inner ramus, with 5 dorsolateral spines, no apical, medial margin with 2 basal setae in tandem and one large curved apically barbed hook-spine; outer ramus shorter than inner, both with 2 rows of marginal spines in formula of S-S and S-eS, apices with 4 and 5 spines. *Third uropod* (Fig. 13): peduncle length 0.50 outer ramus, as long as length of urosomite 3, with several lateral ranks of subdistal setae besides apical cluster of 4 setae and 3 spines, apicomedial corner with spine and seta; outer ramus proximal article with outer (but turned ventrally) comb-row of 12 bifid setae, with transverse lateral spine-seta row on body (3S, 2E), medial margin of apex with 4 spines, lateral margin with 2 spines and 4 setae, apex of large article 2 with 4 apical spines and 3 setae; inner ramus length 0.37 of outer, with 2 apical spines. *Telson* (Fig. 13): broader than wide, shorter than urosomite 3; cleft 70 percent of its length; apices each with spine in lateral notch, 2–3 apical and 1 apicolateral setae, each lobe with 2 dorsomedial setae and each lobe with pair of penicillate setules dorsolaterally at M.55.

**Description of allotype** (female “h”). *Body* (Fig. 8): length, 3.60 mm. Like male but antennae shorter, antenna 2 short and slender, article 5 almost as long as 4; head sinus smaller; coxae slightly taller, coxal setae slightly sparser, bilobation of coxa 7 weaker; gnathopod 2 (Fig. 10) small, similar to but slightly larger than gnathopod 1 (Fig. 9), carpi of gnathopods 1–2 shorter than on male gnathopod 1, lobation distinct on female gnathopod 2, latter with only 1 medial spine, 1 lateral defining spine on palm; oostegites of coxae 2–3 (Fig. 10) large, ovate, of coxa 4 smaller, of coxa 5 very small. Sternal gill formula distinctive (Fig. 12), segments 2–4 each with pair of more or less central gills, segments 5–6 each with 2 pairs, each pair lateral, and segment 7 with 1 pair, each member attached laterally. Armaments of epimera (Fig. 13) short and several comprising spines, formula of epimera 1–3 = E--ES, EE--S, S, e; uropod 3 (Fig. 13) relatively smaller than in male, subdistal armaments sparser, ventrolateral comb of outer ramus absent, replaced by pair of spines in notch, but apex of article 2 better developed, with 7 spines and 3 setae; telson (Fig. 13) more embryonic in appearance, apical spine on each lobe more central, setae fewer but dorsomedial setal pair relatively more basal.

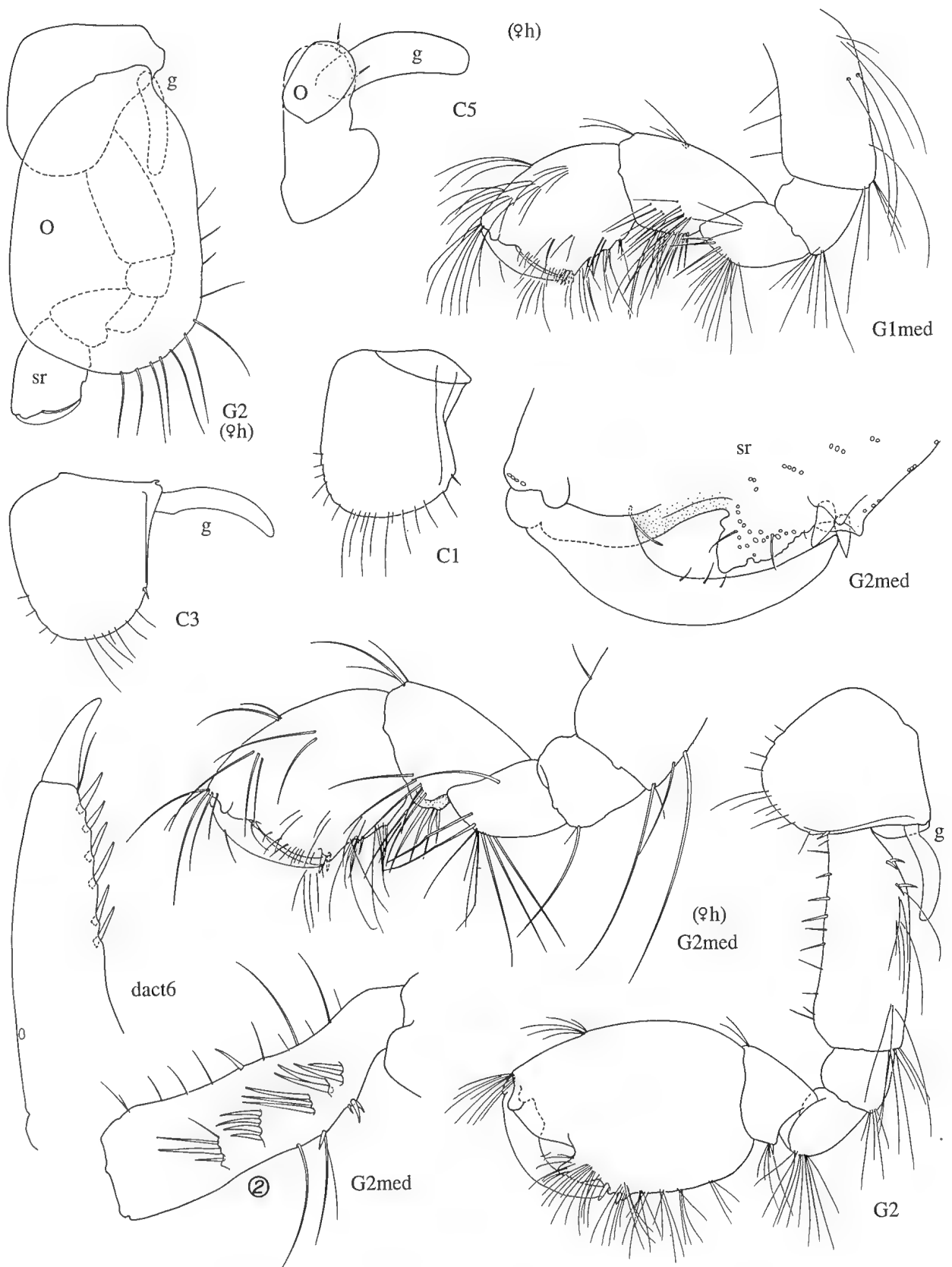


Fig. 10. *Uroctena whadjukia* n.sp., holotype, male "g" 7.09 mm (all drawings except those indicated); female "h" 3.60 mm.

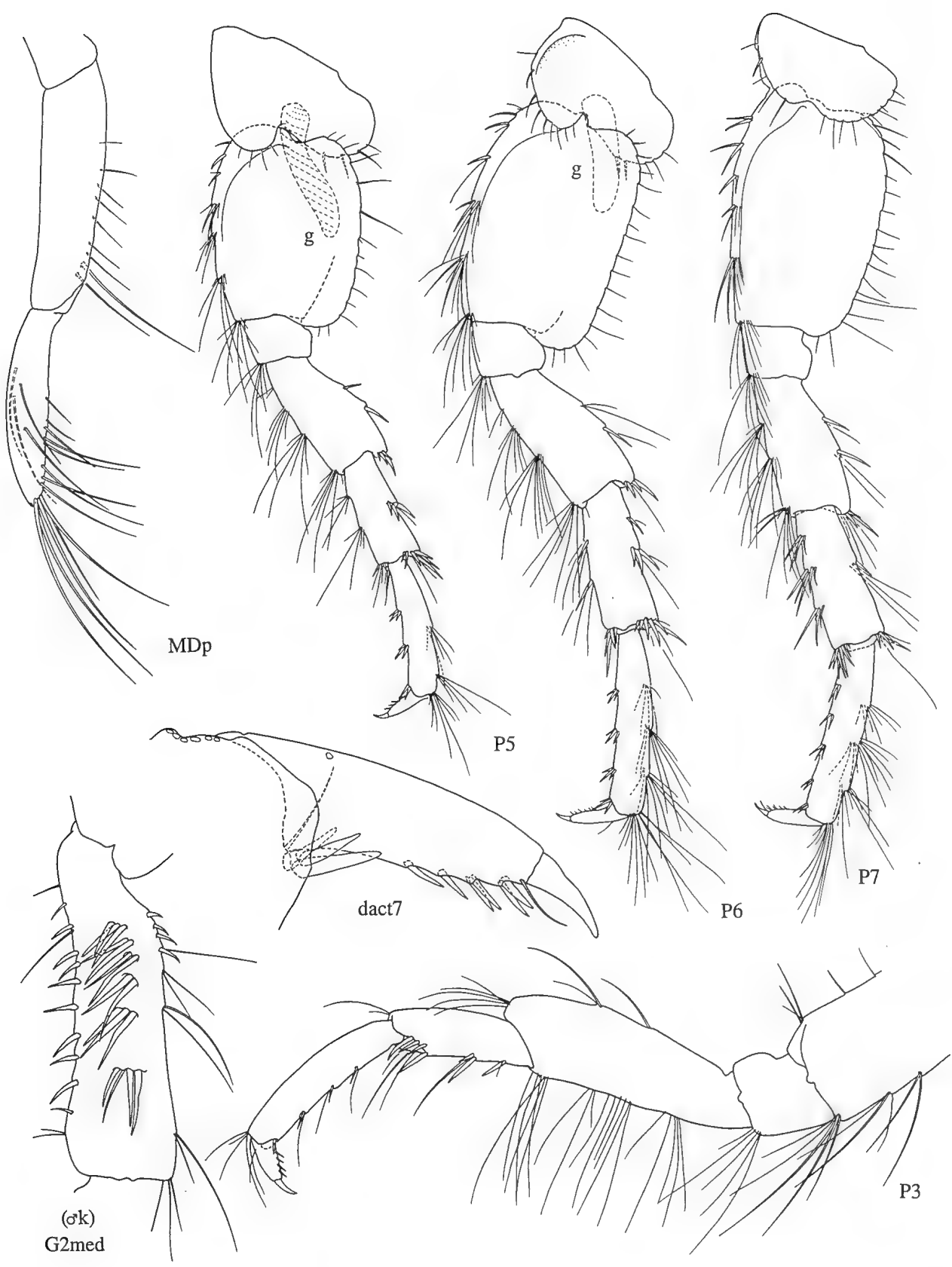


Fig. 11. *Uroctena whadjukia* n.sp., holotype, male "g" 7.09 mm (all drawings except those indicated); male "k" 7.19 mm.

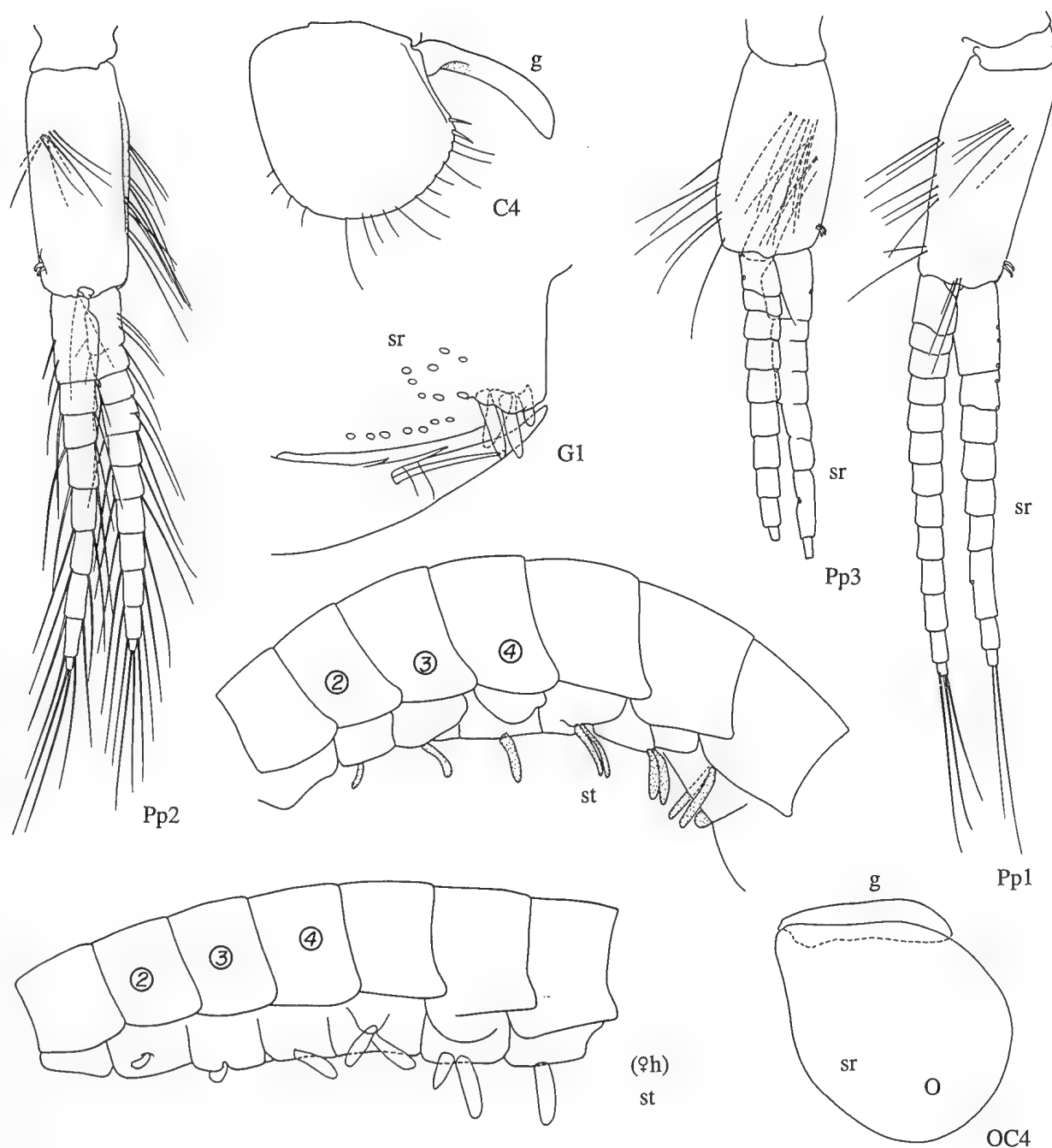
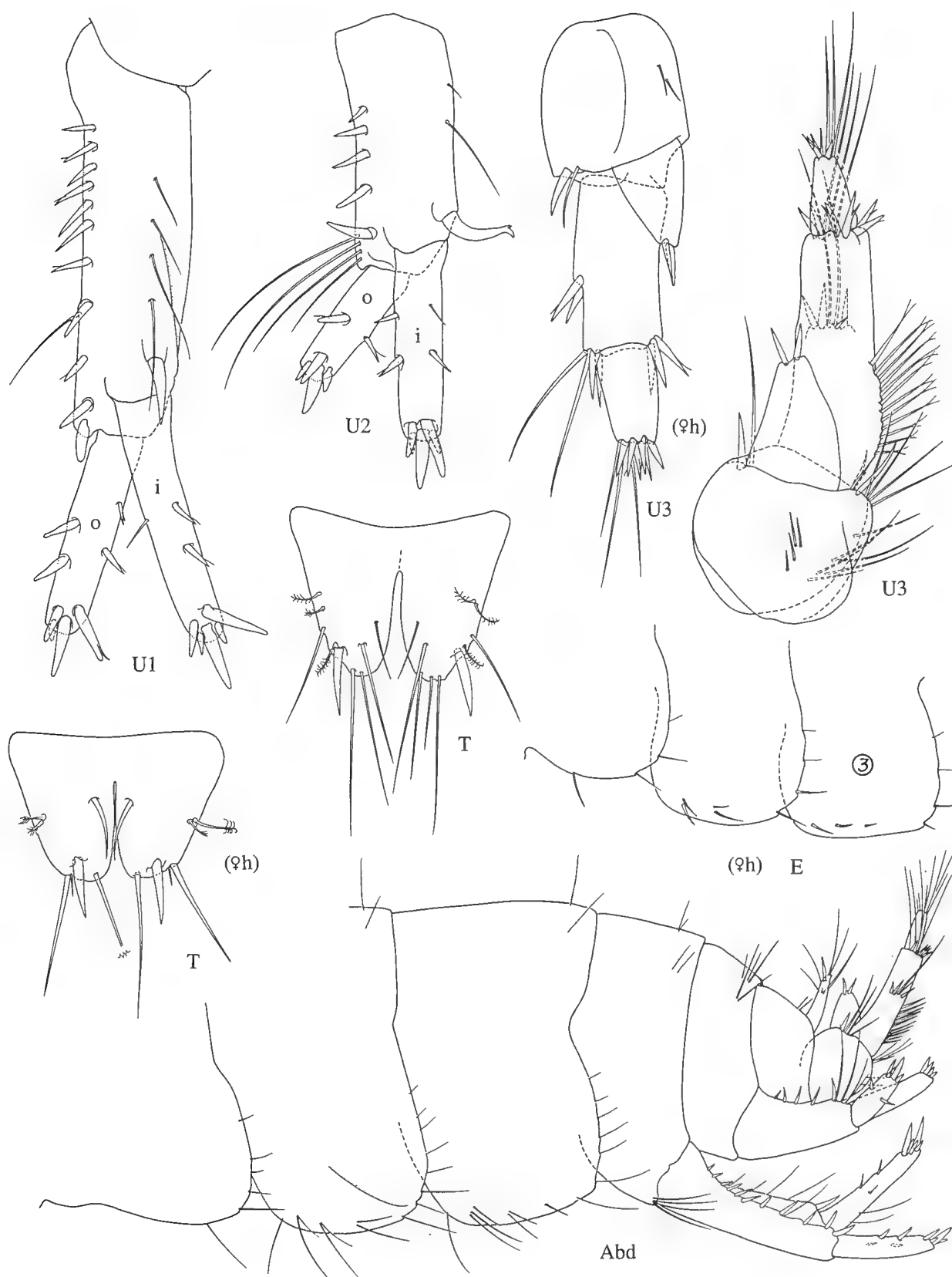


Fig. 12. *Uroctena whadjukia* n.sp., holotype, male "g" 7.09 mm (all drawings except those indicated); female "h" 3.60 mm.

Additional notes of minor items: mandibular palp article 2 with 4 setae, article 3 formula = 3A, 3B, 3D, 5E, left rakers 6; left maxilla 2 palp with 5 thin apical spines and 2 setae; armament formulae on article 5 of pereopods 3 and 4: SS-S-SS and SS-S-SSS, on article 6 = E-ES and ES-ES-SS, dactyls each with 2 spines; locking spines on pereopods 5-7 = 3S+E, dactylar spines = 2-2-4. Formulae on pleopods 1-3: articles of outer rami = 7-7-5, inner rami = 5-5-4, setae on each

peduncle = 5-3-5, setae on outer and inner basal articles of outer and inner rami of pleopods 1-3 = 3-1-1-3, 2-1-1-2, 1-1-1-2, outer rami shorter than inner. Posteroventral spines on urosomite 1 = 2; uropodal spine and setal formulae: uropod 1 peduncle dorsolateral = S-S-S-S-SES, medially = E-S, outer ramus of uropods 1-2 lateral and medial spines = 1-1 and 0-1, inner ramus = 0-1 and 0-0, apical spines of outer and inner rami of uropods 1-2 = 4-5 and 4-5.



**Fig. 13.** *Uroctena whadjukia* n.sp., holotype, male "g" 7.09 mm (all drawings except those indicated); female "h" 3.60 mm.

**Description of other material.** Specimen "k" (Figs 8, 11): male, length 7.19 mm. Slightly more advanced than male "g", pattern of spines on article 2 of gnathopod 2 slightly distinctive (see Fig. 11). Flagellum of antenna 1 with 21 articles, of antenna 2 with 10, calceoli absent. Pereopods 5–6 each with 4 locking spines and one seta, of pereopod 7 with 3 locking spines and one seta. Dorsolateral margin of peduncle on uropod 1 with 12 spines and 2 setae, of uropod 2 with 6 spines and 5 setae.

Specimen "j" is hatchling in brood pouch of female "h". Generally appearance embryonic, body and appendages of swollen appearance, rostrum absent; accessory flagellum 2-articulate, large; flagellar articles of antenna 1 = 5, of antenna 2 = 4; setae of coxae 1–4 = 2-1-1-2; palmar defining spines of gnathopods 1–2 = 1 lateral seta, 1 medial seta and spine; spine formula on article 5 of pereopod 4 = 0-1-1, on article 6 = 0-2; locking spines on pereopods 3–7 = 2, on pereopod 5 but less so on pereopods 6–7 one spine about two-thirds as long as dactyl, all dactyls with 1 seta and one spine; setae on pleonites 1–4 = 2 on each side and 1 fully dorsal; on pleonite 5 = 1 lateral each side and 1 fully dorsal; absent on pleonite 6; all rami of pleopods 1–3 with 2 articles each; epimera 1–3 each with only 1 seta each at posteroventral corner; formulae on uropod 1 peduncle apicolateral = 1, uropod 2 = 1; rami of uropods 1–2 lacking marginal spines, all with 4 apical spines each; peduncle of uropod 3 lacking spines, inner ramus with 1 apical spine, article 1 of outer ramus with 1 apicomedial and 1 apicolateral spine, article 2 with 2 medium and 1 short apical setae; each lobe of telson with 1 apical spine, 1 apicolateral penicillate setule and 2 dorsolateral penicillate setules.

**Relationship.** This species differs from the type species of the genus, *U. affinis*, in the much smaller number of posterolateral spines on article 2 of male gnathopod 2; *U. affinis* bears four sets of three to four each, whereas this species has two sets of two each. In this species there are also no spines on gnathopod 2 propodus besides the defining spines, and the dactyl of gnathopod 1 reaches the apex of the palm. Note that many items of *U. affinis* are unknown such as setation sizes and patterns on pereopods, uropods, epimera, and medial antenna 1.

**Distribution.** Western Australia, Wungong System, creek.

### *Uroctena setosa* Nicholls

Figs 14–17

*Uroctena setosa* Nicholls, 1926: 107–108, pl. 12, figs 1–6, pl. 13, figs 7–9. — Straskraba, 1964: 128–130, figs 4–5. — Williams & Barnard, 1988: 100–103, figs 58, 59.

As previously indicated (Williams & Barnard, 1988: 100), we do not accept Straskraba's (1964) amplified

description of this species; his amplification was not based on material from the type locality and he provided no evidence that the material he described did in fact agree with the material described by Nicholls (1926). Our own previous redescription was based on the text and drawings of Nicholls (1926) and we reserved judgement on whether material in the Western Australian Museum (WAM 478-86 [1 slide], 481–86 [3 slides], all in poor condition) represents type material. We still do. Our description, in the circumstances, was less than complete and contained many indications of where further information was required. We have now been able to procure additional material from the Western Australian Museum from the Nicholls collection. This is in good condition and we judge it to be conspecific with the taxon described by Nicholls (1926) as *U. setosa*. Its description enables us to clarify many points of uncertainty.

**Material examined.** WAM 93-74, "From either Kalamunda Mundaring Swan R or Moora Prof Nicholls coll, n", 11 specimens, including male "c", 7.59 mm (illustrated), female "d", 5.50 mm (illustrated), male "e", 3.91 mm and male "f", 3.37 mm.

**Description (male "c").** *Body:* urosome well armed dorsally; length, 7.59 mm.

*Head* (Fig. 14): rostrum obsolescent; eyes absent.

*First antenna* (Fig. 14): length 0.40 of body, 1.1 length of second antenna; peduncular article 1 longest, article 3 shortest, setae sparse; flagellum 1.4 as long as peduncle, poorly setose, primary flagellum with 18 articles, accessory flagellum 4-articulate, reaching to article 5 of main flagellum. *Second antenna* (Fig. 14): length 0.37 body, almost pediform; peduncle longer than flagellum, article 4 scarcely longer than 5, articles 3, 4 and 5 with dense ventral setation; flagellum 9-articulate, densely setose, lacking calceoli.

*Left mandible* (Figs 14, 17): palp article 3 shorter than 2, article 2 with 14 inner marginal setae, article 3 with 1A, 1B, 3D, 9E setae; incisor 4-toothed, lacinia mobilis 4-toothed, 3 or 4 (badly preserved) setose accessory blades and 3 interrakers; molar (Fig. 17) bearing short plumose seta, 2 large distal (towards incisor) hooked brushy comb setae and 3 proximal (away from incisor) detached flake-pods. *Right mandible* (Fig. 14): incisor 4-toothed; lacinia mobilis bifid, denticulate, one denticulation moderately extended; accessory blades of 1 (probably aberrant) plumose spine, setae of palp article 3 = 1A, 1B, 3D, 9E. *Left first maxilla:* palp article 2 with 6 thin apical and medial spines and 3 subterminal facial setae, outer plate with 11 spines, most denticulate; inner plate with [?] apical setae (maxillae 1–2 badly eroded or encrusted, unable to analyse fully or illustrate). *Right first maxilla:* palp article 2 with 5 thick apical spines mostly fused to segment, 1 apicolateral thin spine and 1 subterminal apicolateral facial seta. *Second maxilla:* outer plate apicolateral face with 1 thick spinule, apicomedial corner of inner plate with 2 weakly submarginal thick setae and no other marginal setae. *Maxilliped:* palp article 3 with ranks of thin setae

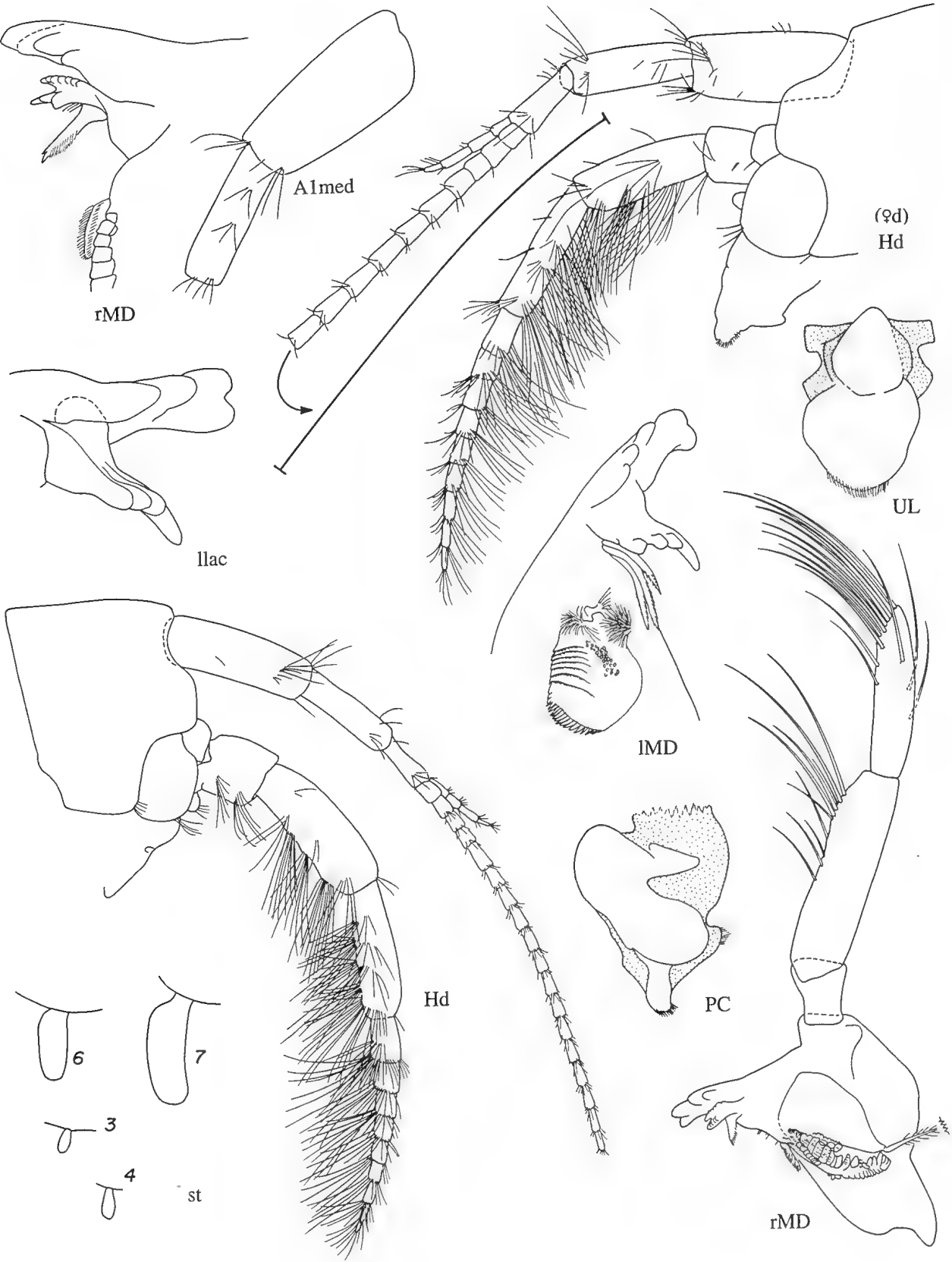


Fig. 14. *Uroctena setosa* Nicholls, male "c" 7.59 mm (all drawings except those indicated); female "d" 5.50 mm.



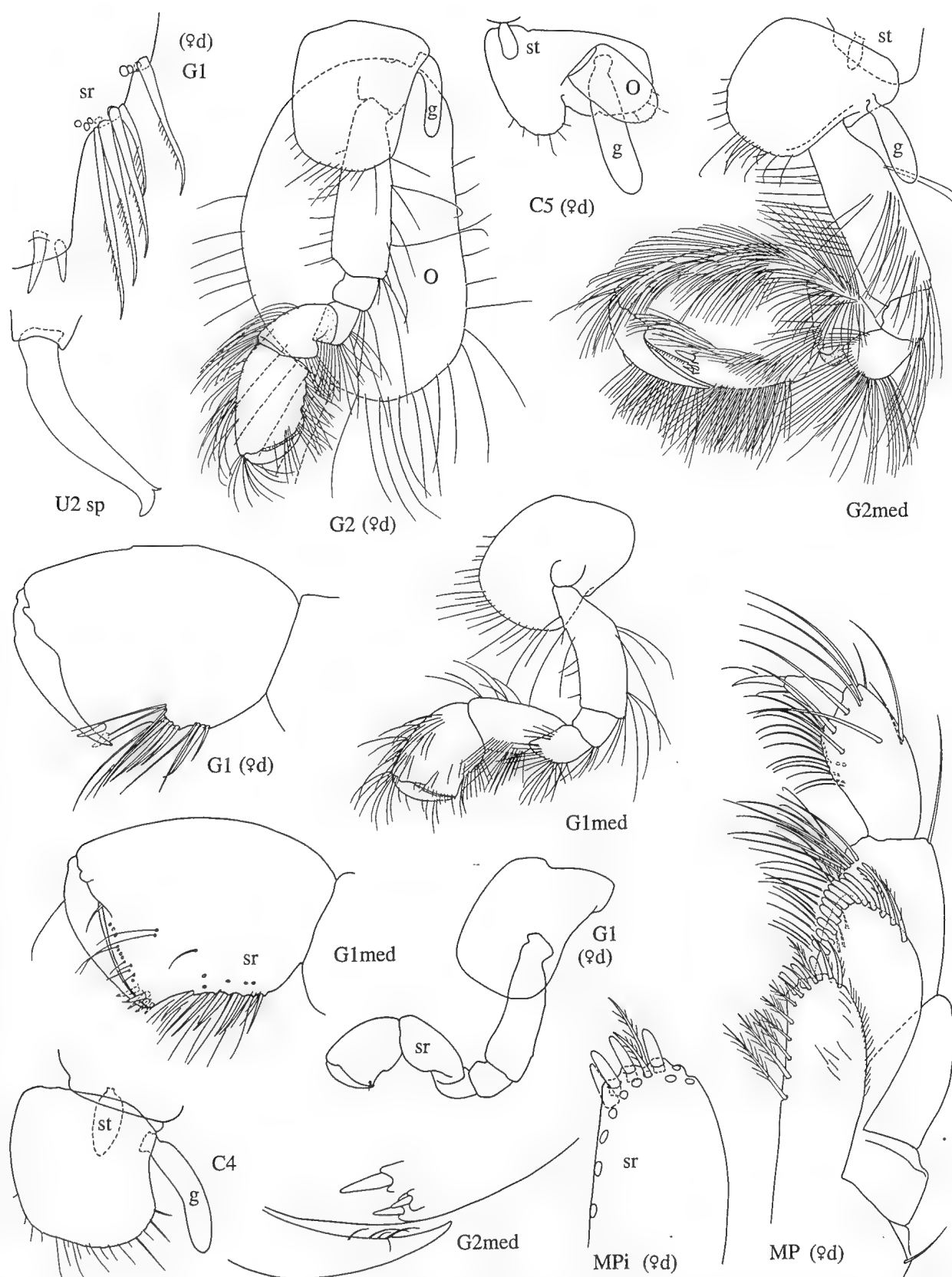


Fig. 15. *Uroctena setosa* Nicholls, male "c" 7.59 mm (all drawings except those indicated); female "d" 5.50 mm.

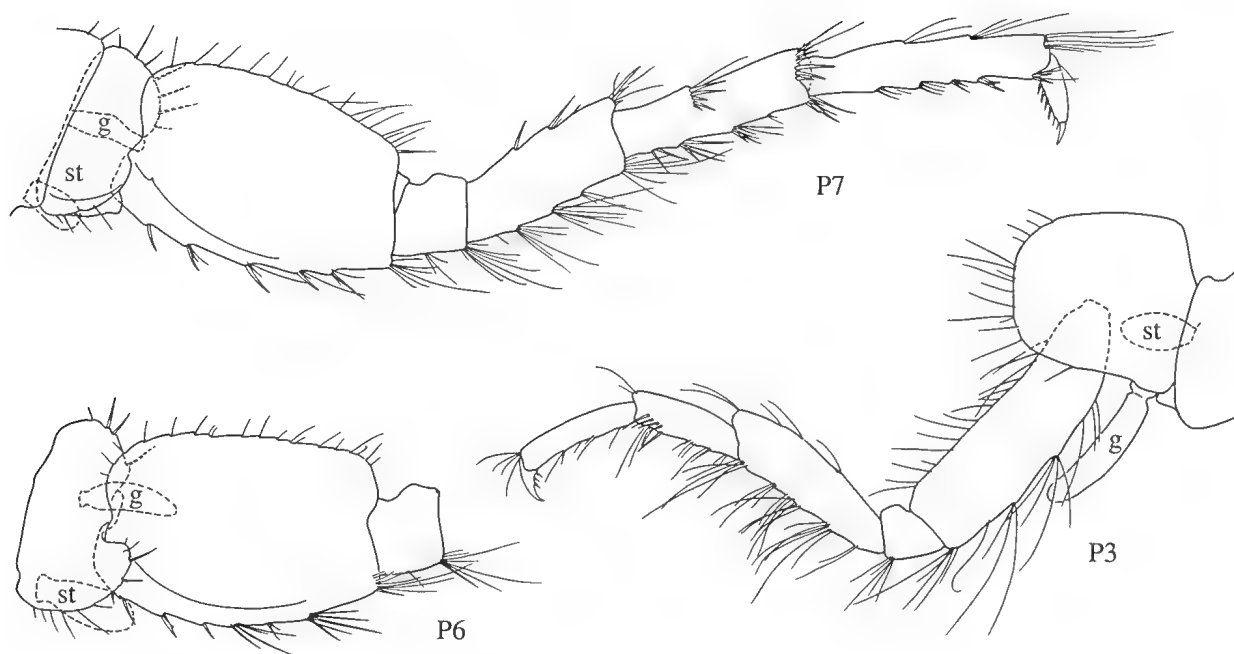


Fig. 16. *Uroctena setosa* Nicholls, male "c" 7.59 mm.

on inner edge, apical part with rank of thicker bifid setae, apex poorly produced and not rugose; inner plate with 3 thick spines and plumose setae apically, medial row of 6 plumose setae, and one ventrofacial spine.

*First gnathopod* (Fig. 15): coxal plate with many long setae ventrally; article 4 without posterior hump; carpus well developed, long and not lobate, with at least 3 rastellae; propodus ovatotrapezoidal, slightly longer than wide, posterior edge with 5–6 heavily setose acclivities, some of these setae approaching thickness of spines, posterolateral angle rounded, with 1 medial and 4 lateral spines, no lateral spines elongate, palm slightly oblique, scarcely convex; dactylus not exceeding end of palm.

*Second gnathopod* (Fig. 15): much larger than first gnathopod; article 2 lacking large spines; carpus short, weakly lobate; propodus huge, ovate, posterior margin almost smooth, setose, palm very oblique, palmar corner with 2 medial spines; very long setae fully present on anterior margins of carpus and propodus and on posterior margins of merus and propodus; coxal plate setose.

*Pereopods* (Figs 16, 17): ventral margins of coxae rounded, with numerous long setae, coxa 4 slightly emarginate, with 4 anteroventral but no posterior setae; pereopods 3–4 longer than gnathopod 2, pereopod 3 longer than 4, article 4 moderately setose posteriorly, article 5 less strongly setose posteriorly, posterior margin of article 6 on pereopods 3–4 with spine-seta (total) formulae of 1-2-1-3-2 and 2-3-1-3-2; pereopods 5–7 similar, 6 slightly longest, coxae with spines on ventral margin of posterior lobe, article 2 expanded and weakly lobate posteroventrally on pereopods 5–6, bearing short to medium posterior setules. Coxal gills sausage-

shaped, of medium size, very slightly decreasing in size in following order: 5, 4, 3, 2, 6; seventh segment with pair of strap-shaped penial processes about size of sixth coxal gills.

*Sternal processes* (Fig. 14): six pairs of fleshy, sausage-shaped sternal gills present on segments 2–7, attached to front of lateral edge of each of segments 5–7, more closely to mid-transverse line and also more central on other segments.

*Epimera* (Fig. 17): each epimeron posteroventrally rounded, posterior margins serrate and setose, epimeron 1 with 3 ventral setae, formula of anterofacial spine-setae on epimera 2–3 = 2-2-1-2-1 and 1-2-1-2-1. *Pleon* (Fig. 17): dorsolateral posterior margin of pleonites 1–3 sparsely setose, pleonites 4–5 with several dorsal groups of dense setae, pleonite 6 with few dorsolateral setules on each side; uropod 3 extending beyond uropods 1 and 2 in entire animal, uropod lengths relative to uropod 1: uropod 2 = 0.67, 3 = 0.67. *Pleopods*: retinacula 2 per pleopod, no accessories; each peduncle well setose; rami of equal extension, articles of outer rami on pleopods 1–3 = 13-11-9, inner = 11-11-9; setae on basal articles, outer margin of outer ramus to inner margin of inner ramus on pleopods 1–3 = 3-2-1-2, 3-2-1-1, 2-1-2-1, no bifid or barbed setae.

*First uropod* (Fig. 17): peduncle length 1.4 rami; outer margin with 3 apicodistal spines and 3 setae besides row of 7 dorsal spines, with one apical spine medially and row of 4 widespread medial setae; rami of subequal length, both rami with 2 rows of marginal spines, ramus with 5 apical spines. *Second uropod* (Fig. 17): peduncle about 1.1 length of inner ramus, with 3

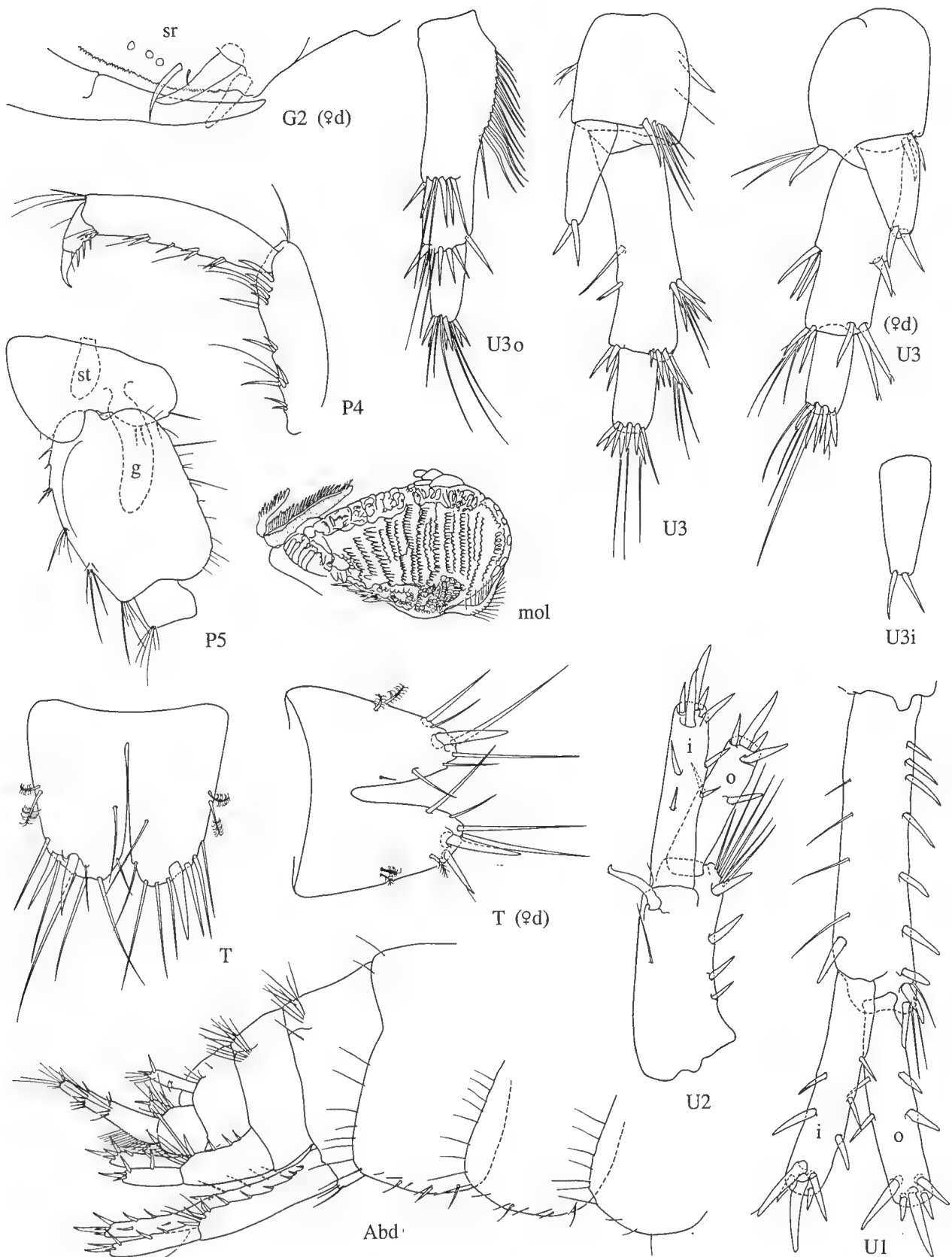


Fig. 17. *Uroctena setosa* Nicholls, male "c" 7.59 mm (all drawings except those indicated); female "d" 5.50 mm.

dorsolateral spines and 1 apical, with 6 apical setae, medial margin with hooked and barbed apical spine (Fig. 15) and one medial seta; outer ramus shorter than inner, both with 2 rows of marginal spines, apices with 5 and 4 spines. *Third uropod* (Fig. 17): peduncle length 0.44 outer ramus, almost as broad as long, shorter than urosomite 3, with 3 lateral long setae besides apicolateral spine and 5 setae; outer ramus proximal article with one lateral spine-setal cluster on body, ventrolateral margin with comb of about 14 short stiff bent setae on flange, distolateral margin with 6 spines and 3 long seta, apicomедial margin with 4 spines, medial margin with 2 spines, distal article large, with 7 apical spines and 4 long setae: inner ramus length 0.36 of outer, with 2 apical spines. *Telson* (Fig. 17): of ordinary length, shorter than urosomite 3; cleft 80 percent of its length; apices each with 1–2 spines and 7 setae; each lobe with 1–2 dorsal setae, and pair of penicillate setules dorsolaterally at M.50.

**Description of female “d”.** Up to 5.5 mm long. *Antenna* (Fig. 14). First antenna as long in relation to body as in male if not longer but second antenna 0.33 length of body. *Second antenna* (Fig. 14) more slender than in male and scarcely pediform, densely setose but less so than in male, article 4 of peduncle not longer than article 5, flagellum with 9 articles.

*Mandibles.* Right mandible with 2 rakers, interrakers 2; molarial seta elongate; incisor with 4 teeth; left mandible with 4 rakers, 4 interrakers, molar with 6 leaflobes, seta short, with 2 major hook-comb setae and one rudimentary; left palp setae, 1A, 1B, 2D, 7E.

*Gnathopods and pereopods.* First gnathopod (Fig. 15): smaller even than male gnathopod 1, propodus less expanded: 1 medial and 1 lateral spine at defining corner of palm. Second gnathopod (Fig. 15): somewhat larger than gnathopod 1, armament of defining corner of palm similar. Gnathopods 1–2 much more setose than in female of *U. westralis*, with especially long tufts of setae anteriorly on carpus and propodus and posteriorly on merus. Coxae 2–4 with huge oostegite (Fig. 15), that of coxa 5 very small. Coxal gills slightly smaller than in male. Sternal gill number 7, gills slightly larger than in male (relative to surrounding structures), gill 6 as large as in male, then sternal gills 5, 4, 3 and 2 progressively smaller until gill 2 less than half length of article 3 on gnathopod 2. Volume occupied by sternal gills in male filled with 9 hatched juveniles in female.

**Illustrations.** Maxillae 1–2 not illustrated; in poor condition. Lower lip as in other Australian crangonyctoids. Maxillipeds of specimen “c” also in poor shape, illustration thus made of specimen “d”.

**Remarks.** The male differs from the concept of this species proposed by Williams & Barnard (1988) based on the literature in the following ways: the urosome is densely armed dorsally, the posterior margins of the propodi on gnathopod 1 in both sexes have some setae sufficiently thickened to be denoted as spines, the telson

is cleft 80 percent (versus 50) and male uropod 3 has a rank of spines laterally beyond the basal comb of setae. The figure of male gnathopod 1 as copied from Nicholls in our figure 58 (Williams & Barnard, 1988) may actually be a female gnathopod 2, although the so-labelled female gnathopod 2 is not very different from that one we show herein; if the male gnathopod 1 is indeed as shown by Nicholls, then he probably had a far more mature male than ours.

**Relationship.** Differing from all other species of *Uroctena* in the lack of facial spines on article 2 of male gnathopod 2 and the much higher degree of setation on the gnathopods and antennae 1–2 of both sexes. Article 2 of male gnathopod 2 does possess many setae, but no stiff thick spines.

**Distribution.** Western Australia, reservoir at Katanning.

### *Chillagoe* n.gen.

**Etymology.** Named for the type locality.

**Type species.** *Chillagoe thea* n.sp.

**Diagnosis.** Pleonites with few dorsal spines and setae. Rostrum obsolescent, lateral cephalic lobes strongly projecting and moderate antennal sinus present. Eyes absent.

Antenna 1 moderately elongate, longer than antenna 2, ratio of peduncular articles about 19:14:9, accessory flagellum 2-articulate. Flagellum of antenna 2 much shorter than peduncle, calceoli absent.

Ratio of mandibular palp articles about 9:12:8, article 2 moderately setose, article 3 ovate, setae = DE. Labium lacking inner lobes. Maxillae barely setose medially, inner plate of maxilla 1 tapering distally, with 2 apical setae, outer plate with 9 spines, palps asymmetric, one side with thin apical spines, other side with thick but articulate apical spines. Inner plate of maxilla 2 lacking oblique row of setae on face, with one apicomедial seta slightly submarginal.

Coxae 1–4 short, but slightly longer than broad, coxae 1–3 lacking row of posterior spines, coxa 1 not expanded below, coxa 4 scarcely lobate, coxa 5 shorter than 4. Gnathopods enlarged in female (male unknown), carpi short, lobate, fourth article lacking hyaline lobe, palms strongly oblique, lacking rugosities, spines not symmetrically bifid, rather with small subapical trigger-like extensions; spines at corner of palm 7+; small spinules along palm sparse and simple.

Pereopods 5–7 elongate, pereopod 6 longer than pereopod 7, article 2 moderately expanded, ovate and posteroventrally lobate: dactyls of pereopods 3–7 with 0–1 spinules on inner edge besides ordinary 1 setule.

Coxae 2–6 each with gill, gill 6 not reduced. Oostegites slender. Thoracic segments 2–6 each with mid-ventral pair of sternal gills of sausage form.

Uropod 3 well extended, peduncle short, outer ramus 2-articulate, article 2 tiny, inner ramus absent. Telson slightly elongate, cleft about 70 percent, lobes not tumid laterally, with one apical spine on each lobe, no lateral armaments except for pair of lateral penicillate setules about M.70 on each side.

**Additional description.** Upper lip uniform, rounded and symmetrical below. Accessory blades (rakers) on mandibles 4–6, usually with interraker plumose seta between each main raker; few additional penicillate setae beyond rakers and riding on to base of molar, with regular apical molarial seta. Both plates of maxilla 2 with long apical setae; inner plates of maxillae 1–2 and outer plate of maxilla 2 covered with pubescence. Maxillipedal inner plate long, with distal row of several plumose setae and 2 blunt naked spines, and medial row of 3 plumose setae; outer plate of medium size, without distal plumose setae, with medial row of blunt or pointed naked tooth-spines; palp articles 2–3 poorly setose or not laterally, article 2 moderately setose medially, article 3 lacking organised comb row of spines near base of dactyl, apex barely produced, not rugose.

Dactyls of gnathopods without small recumbent inner tooth-spine but with stiff setule(s) at inner nail articulation line. Gnathopod 1 without one rastellate seta of article 4 enlarged and scythe-like. Pereopods 3–4 proportional to pereopods 5–7. Posterior spine sets on article 6 of pereopods 3–4 evenly spaced (one aberration shown). Pleopods similar, peduncles not setose; outer rami slightly shortened in female; basomedial setae on inner rami of pleopods not bifid; retinacula 2, accessory retinacula absent.

Posteroventral tooth of epimera 1–3 absent but posterior margins sparsely setulose; some epimera with facial spines and setae near ventral margin. Apicolateral corner of peduncles on uropods 1–2 with 3–2 spines, dorsal margins spinose, medial margin of uropod 1 with only one apical spine; rami of uropod 1 extending subequally, outer ramus of uropod 2 shortened, margins spinose, uropod 1 bearing basofacial spine; only inner rami of uropods 1–2 with 2 spine rows. Medial setae of outer ramus on uropod 3 absent; with subdistal peduncular seta. Ventrodistal spine on urosomite 1 at base of uropod 1 moderately developed.

**Sexual dimorphism.** Unknown. Because female gnathopods enlarged, male gnathopods presumably also enlarged; setosity of male uropod 3 and subsidiary armaments and size of antennae unknown.

**Relationship.** This is the second Australian genus to lack an inner ramus on uropod 3. *Chillagoe* differs otherwise from *Giniphargus*, which also lacks this structure, in the enlarged gnathopods, 2-articulate (versus 4-articulate) accessory flagellum, strongly reduced article 2 on the outer ramus of uropod 3, much less vermiform body shape, unthickened antenna 2, presence of basofacial spine on uropod 1, and loss of medial setation on the maxillae.

*Chillagoe* closely resembles the pseudoniphargid group of east Asia. The uniramous uropod 3 is a strongly correlative feature but *Chillagoe* differs from pseudocrangonyctids in the well-developed mandibular molar, the nature of the outer rami of uropods 1–2, the slightly deeper telsonic cleft, and the fully developed 9 spines (versus 6–7) on the outer plate of maxilla 1. Owing to the great distance across tropical and marine frontiers between Japan and Australia, the pseudocrangonyctids and *Chillagoe* may be convergent derivatives from two different root stocks. The presence of sternal gills in the two groups suggests an origin from basic crangonyctoid root stocks. It may also have affinities with *Sternophysinx* from caves in South Africa (J.R. Holsinger, pers. comm.). For the present, the taxon is regarded as a somewhat aberrant paramelitid. In any event, the lack of rugosities on its gnathopods, *inter alia*, clearly exclude it from the Neoniphargidae, and the form of its sternal processes (gills), *inter alia*, from the Perthiidae, the only other recognised Australian families of crangonyctoids.

#### *Chillagoe thea* n.sp.

Figs 18–20

**Etymology.** Named for the type locality.

**Type locality.** Tea Tree Cave, from freshwater pool in cave, Chillagoe, Queensland.

**Material examined.** HOLOTYPE (Australian Museum, P44066), female “k” 5.81 mm, in type series collected 22 August 1973, A.V. Spain collector. Other material from type series (PARATYPES), female “l” (P44067) 4.98 mm, female “m” (P44068) 5.27 mm, female “n” (P44069, unmeasured), juvenile “o” (P44070) 3.80 mm and 23 other specimens (P44071, no males). Other material: same locality, 23 August 1973, A.V. Spain collector, 9 specimens (P44072).

**Diagnosis.** As in the genus.

**Description of holotype (female “k”).** *Body* (like *Protocrangonyx* in Williams & Barnard, 1988, fig. 63): pleon poorly armed dorsally, armament bilateral, total dorsal setae on pleonites 1–3 = 2–4–4, spinules on pleonites 4–6 = 2–2–0; length, 5.8 mm.

*Head:* rostrum obsolescent; eyes absent.

*First antenna:* length 0.53 of body, 1.6 second antenna, flagellum longer than peduncle, peduncular article 1 longest, article 3 shortest, setae sparse, distoventral corner of article 1 with strong spine, flagellum with 17 articles, lacking conspicuous aesthetascs, accessory flagellum 2-articulate, reaching middle of article 2 of primary flagellum, articles uniform after first 4, sparsely setulate. *Second antenna:* length 0.33 body; peduncle longer than flagellum, articles 4–5 of equal length, articles 3, 4 and 5 with poor to moderate ventral setation; flagellum 5-articulate, poorly setose ventrally, lacking calceoli.

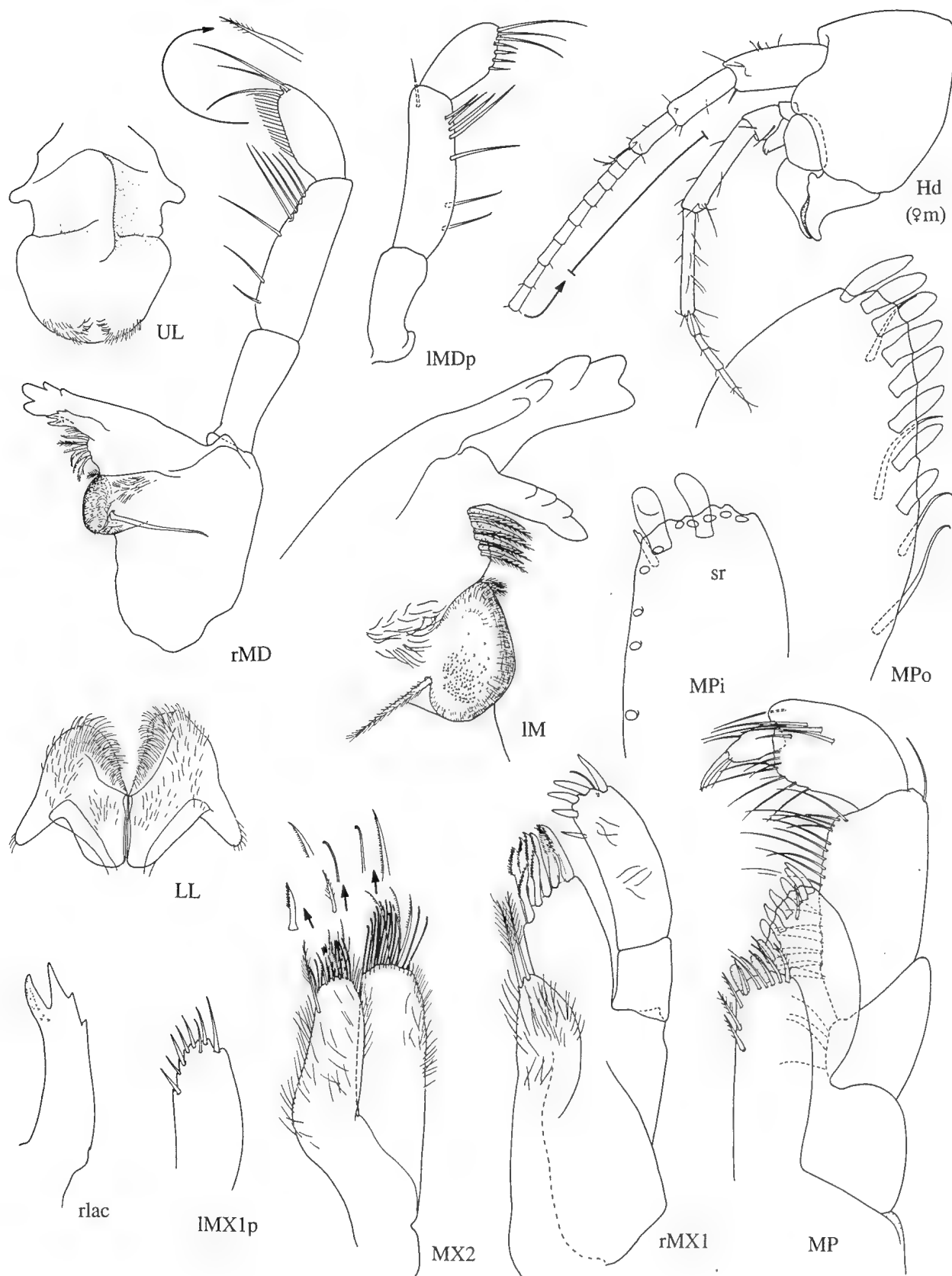


Fig. 18. *Chillagoe thea* n.sp., holotype, female "k" 5.81 mm (all drawings except those indicated); female "m" 5.27 mm.

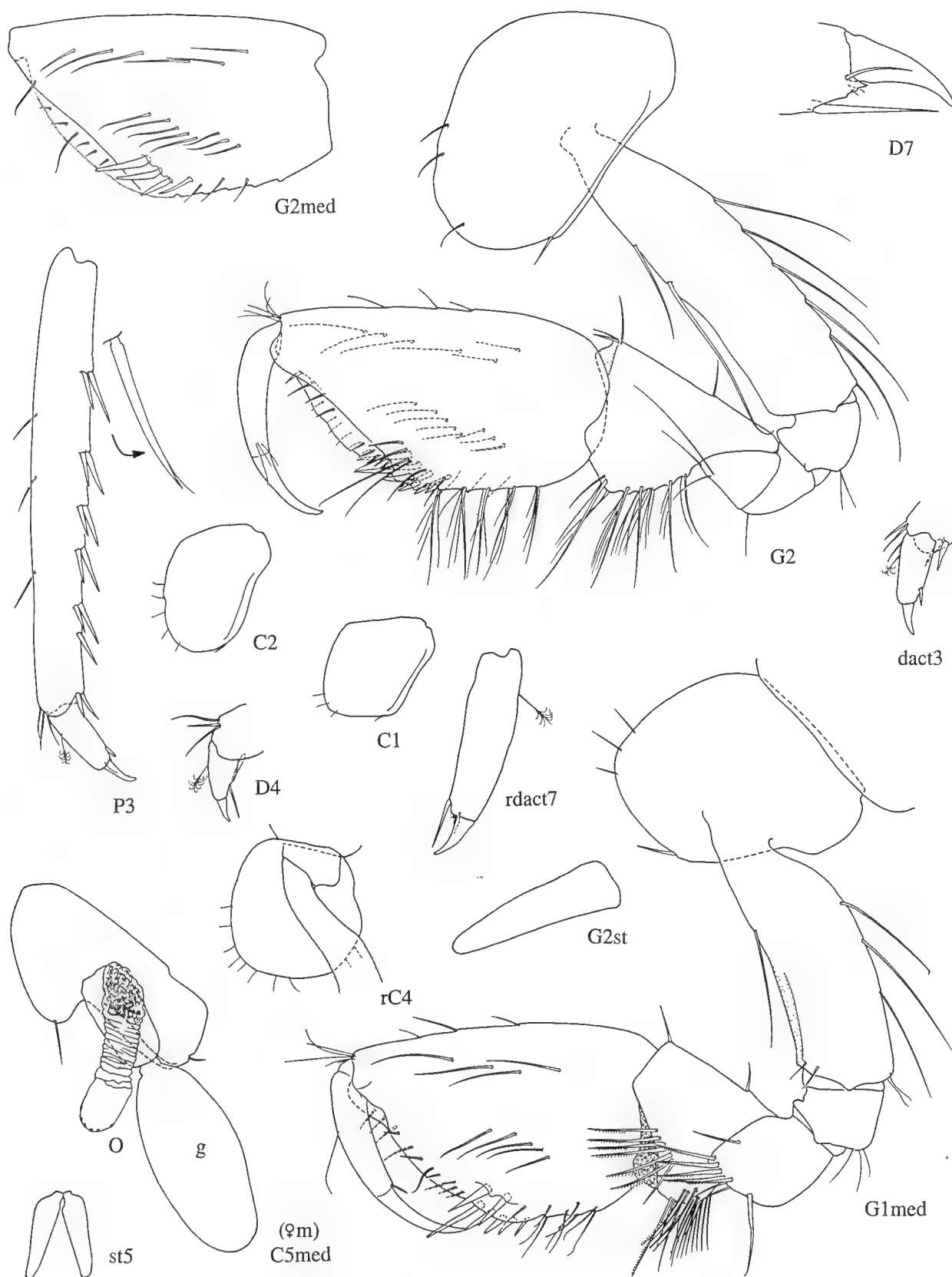


Fig. 19. *Chillagoe thea* n.sp., holotype, female "k" 5.81 mm (all drawings except those indicated); female "m" 5.27 mm.



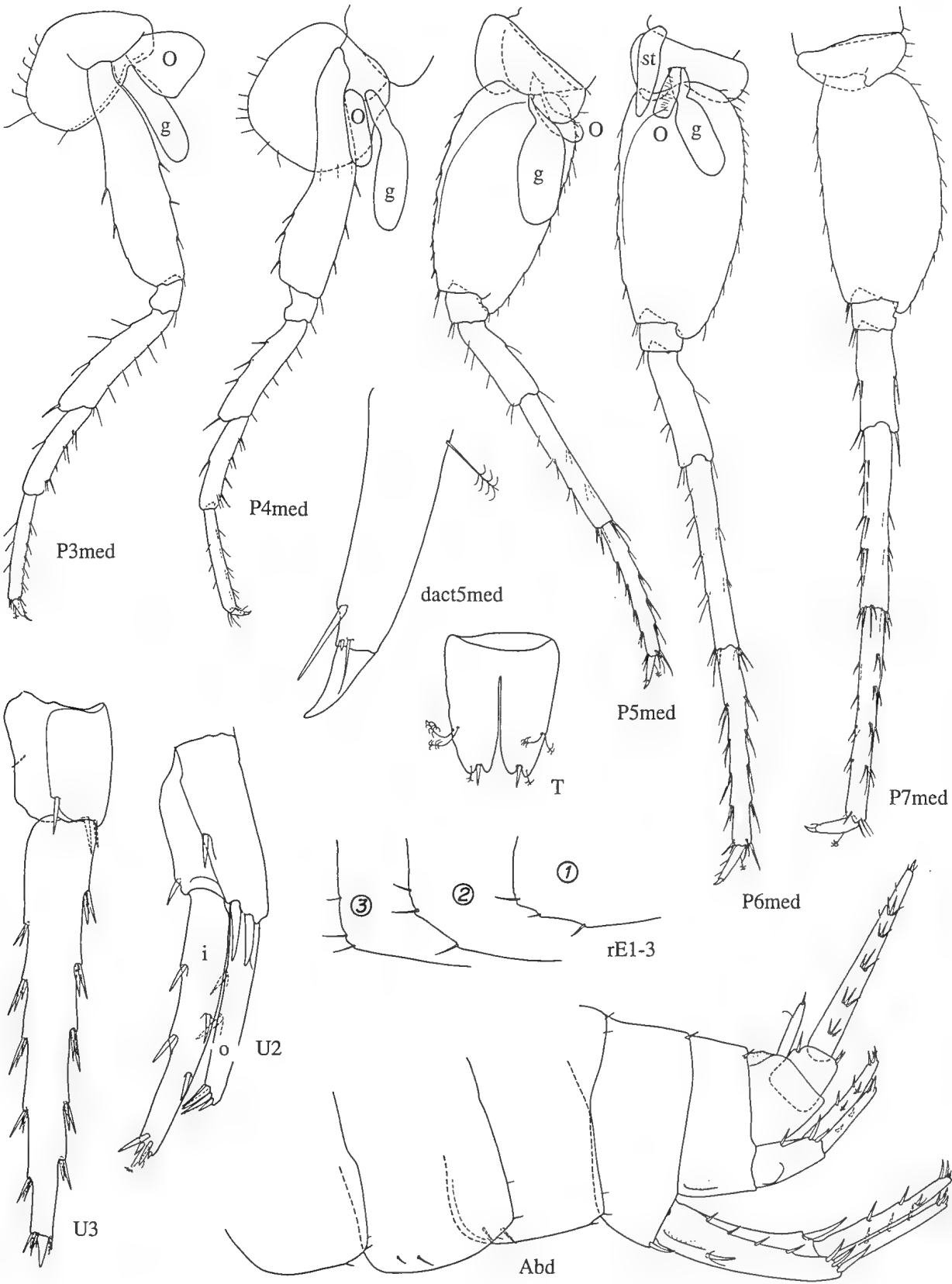


Fig. 20. *Chillagoe thea* n.sp., holotype, female "k" 5.81 mm.

*Upper lip* (Fig. 18): apical margin evenly rounded, connection to epistome and epistome itself symmetrical, epistome with anterior keel. *Lower lip* (Fig. 18): without inner lobes. *Left mandible* (Fig. 18): palp article 3 [aberrant], article 2 with 7 medial marginal setae; incisor 5-toothed, lacinia mobilis 4-toothed, 4 setose accessory blades; molar bearing plumose seta, several penicillate hooked brushy basal setae, other pubescence. *Right mandible* (Fig. 18): incisor 4-toothed; lacinia mobilis bifid, narrow, denticulate; accessory blades of 7 plumose spines, palp article 3 shorter than 2, setae = 15D, 3E. *Left first maxilla* (Fig. 18): palp article 2 with 7 thin apical spines and 1 barely subterminal facial seta, outer plate with 9 spines, most denticulate; inner plate with 2 apicomедial setae. *Right first maxilla* (Fig. 18): palp article 2 with 5 thick apical and medial spines fully articulated to segment, one thin seta apicolaterally. *Second maxilla* (Fig. 18): outer plate outer apical margin without spinule, apicomедial margin of inner plate with 1 weakly submarginal thick seta. *Maxilliped* (Fig. 18): palp article 3 with sparse ranks of thin setae on inner edge, no lateral setae, face with linear row of 3 setae, apex not strongly produced, not rugose; inner plate with 2 thick spines and several plumose setae apically, medial row of 3 plumose setae, and 1 ventrofacial spine; outer plate with 8 thick spines medially.

*First gnathopod* (Fig. 18): coxal plate with 3 short setules anteroapically, with 1 posteroventral setule; article 4 without posterior hump; carpus thick, short, lobate; propodus subrectangular, longer than wide, posterolateral angle rounded, posterior edge with 3 acclivities and 3 sets of setae, with 2 medial and 5 lateral spines, one lateral spine elongate, palm oblique, convex; dactylus reaching end of palm. *Second gnathopod* (Fig. 19): of similar size to gnathopod 1; article 5 short and lobate but longer than on gnathopod 1, article 6 more evenly rectangular, palm oblique, palmar corner with 5 lateral and 4 medial spines, posterior margin with 5 setose acclivities; dactyl strongly curved, fitting palm; setation of coxal plate like coxa 1.

*Pereopods* (Figs 19, 20): coxa 3 with 6 anterior setae and one posteroventral setule, coxa 4 barely emarginate, with 8 anteroventral and 3 posteroventral setae; pereopods 3-4 not longer than gnathopod 2, pereopod 3 scarcely longer than 4, article 4 weakly setose posteriorly, article 5 weakly spinosetose posteriorly, posterior spine formula = se-se-s-2se and se-se-s-2se, posterior margin of article 6 on left pereopod 3 with spine formula of 2-2-2-2-1-2, on right = 2-2-2-2-2-2, on pereopod 4 = 2s-2s-2se-2se-2s; pereopods 5-7 similar, each with 2 locking spines; coxae 5-7 bearing spines or setae on posteroventral margin of posterior lobes, article 2 expanded and lobate posteroventrally, thinner on pereopod 7, bearing thin short posterior setae; dactyls of pereopods 3-7 with one main spinule, one facial setule at nail margin plus tiny accessory setule rudiments. Gills (Fig. 20) of coxae 2-6 sausage shaped, of pereopod 6 not reduced. Oostegites slender but lacking setae, shrivelled basally and appearing short.

*Sternal (gills) processes* (Fig. 19): segments 2-6 with sausage-shaped sternal gills in central pairs.

*Epimera* (Fig. 20): each epimeron posteroventrally

subquadrate, posterior margins scarcely convex, with 1-2 posterior setules, epimeron 1 with 1 ventral setule, epimera 2-3 with facial spine formula of 2-2. *Pleon* (Fig. 20): each dorsolateral posterior margin of pleonites 1-3 with following setal formula, 1-2-2, pleonites 4-6 with dorsolateral spine formula of 1-1-0. Uropod 3 strongly extending beyond uropods 1 and 2 in entire animal, uropod lengths relative to uropod 1: uropod 2 = 0.50, 3 = 0.86. *Pleopods*: retinacula 2 per pleopod, no accessories; peduncles without setae, outer rami shorter than inner by length of 2 inner articles, outer with 10-10-9 articles, inner with 8-8-8 articles, setae on basal articles = 1-1-1-2 on all pleopods, none bifid.

*First uropod* (Fig. 20): peduncle length 1.2 rami; 1 large basofacial spine on outer face; outer margin with 3 apicodistal spines besides row of 4 dorsal spines, with 1 apical spine medially; rami of subequal length, only inner ramus with 2 rows of marginal spines in formula of 2-2, with outer ramus with 2 ventromedial spines, each ramus with 4 apical spines. *Second uropod* (Fig. 20): peduncle about 0.75 length of inner ramus, with 1 dorsolateral spine, 2 apicals, medial margin with one apical spine; outer ramus shorter than inner, with 2 dorsomedial spines, only inner ramus with 2 rows of marginal spines in formula of 2-2, apices each with 5 spines. *Third uropod* (Fig. 20): peduncle length 0.28 outer ramus, longer than urosomite 3, with one medial seta, one dorsolateral and 2 ventrolateral spines; outer ramus proximal article with 5 lateral and 5 medial ranks of 2-3 spines each, apicolateral corner with 2 spines, apicomедial corner with 5 spines; article 2 small. *Telson* (Fig. 20): 1.25 longer than wide, scarcely shorter than urosomite 3; cleft 70 percent of its length; apices each with spine in notch, 1 apical setule, and each lobe with pair of penicillate setules dorsolaterally at M.70.

Notes of minor items on holotype: left mandibular palp article 2 with 7 medial setae, one seta on apicodorsal corner unlike right palp, setae of article 3 = 4D, 3E.

**Description of other material.** Specimen "l": female, length 4.98 mm. Left mandibular palp article 3 with setal formula of 14D, 4E (thus left palp on holotype is abnormal); left article 6 of pereopod 3 with posterior spine formula of 2-1-2-2-2-2; epimeron 1 lacking posterior setule, face of epimeron 2 with only 1 spine, epimeron 3 lacking direct posterior setule, one at corner present; inner ramus of uropod 1 with 3 marginal spines; lateral margin of ramus on uropod 3 with only 4 sets of spines.

Specimen "o": juvenile, length 3.80 mm. Epimeron 1 lacking ventral spine, epimera 2-3 each with 1 facial spine, only one posteroventral spine; uropod 1 as in holotype, uropod 2 like holotype but outer ramus with only 1 marginal spine, inner ramus formula, lateral = 0-1, medial = 1-1; outer ramus of uropod 3 with only 4 lateral sets of spines.

Specimen "m" (Figs 18, 19): female, length 5.27 mm.

**Distribution.** Queensland, Chillagoe, Tea Tree Gully, from freshwater pool in cave.

## "Melitoid" Genera

### *Brachina* n.gen.

**Etymology.** Taken from one of the localities of the type species.

**Type species.** *Brachina invasa* n.sp.

**Diagnosis.** Body slender but not vermiform. Pleonites with sparse dorsal spines and setae. Rostrum obsolescent, lateral cephalic lobes weakly projecting and weak antennal sinus present. Eyes absent.

Antenna 1 elongate, longer than antenna 2, ratio of peduncular articles about 19:18:10, accessory flagellum 3 articulate. Flagellum of antenna 2 much shorter than peduncle, calceoli absent.

Mandibular palp only 2-articulate, ratio of articles about 8:21, article 2 sublinear, truncate, setae only. Labium lacking inner lobes. Maxilla 1 with apical setose setae on inner plate, outer plate with 7 (aberrantly 8) spines, palps symmetrical, with thin apical spines. Inner plate of maxilla 2 with medial margin sparsely setose halfway to base.

Coxae 1–4 of medium length, longer than broad, coxae 1–4 lacking posterior spines, coxa 1 not expanded below, coxa 4 well lobate, coxa 5 shorter than 4. Gnathopods diverse, gnathopod 1 small and of melitoid form (see Barnard & Barnard, 1983), carpus long, not lobate, fourth palm transverse, lacking rugosities, spines not symmetrically bifid, rather with small subapical trigger-like extensions; spines at corner of palm 7+; small spinules or setules along palm sparse and simple. Gnathopod 2 enlarged, carpus short, weakly lobate, propodus almond-shaped, palm very oblique, dactyl fitting palm, spines at corner 2, small spinules along palm not bifid, posterior margin of propodus with about 4 groups of thick setae each tapering rapidly and several strongly curved apically, setae however short relative to most extreme of hadzioid genera (see Barnard & Barnard, 1983).

Pereopods 5–7 elongate, pereopod 7 longer than pereopod 6, article 2 moderately expanded, ovate but only posteroventrally lobate (weakly) in pereopod 5; dactyls of pereopods 3–7 without spinules on inner edge besides ordinary articulation setules (3).

Coxae 2–6 each with large pedunculate gill, gill 6 not reduced. Oostegites slender. Sternal gills absent.

Uropod 3 well extended, parviramous, peduncle short, outer ramus 2-articulate, article 2 small, inner ramus short and scale-like. Telson shorter than broad, fully cleft, lobes tumid laterally, with 3 apical spines on each apically cuspidate lobe, with one basolateral spine at M.37, one medial spine at M.70, pair of lateral penicillate setules near lateral apex on each side.

**Additional description.** Upper lip uniform, rounded and symmetrical below. Accessory blades (rakers) on mandibles 3, without interraker setae; several additional comb setae on distal surface of molar, with regular apical molarial seta. Both plates of maxilla 2 with long

apical setae; inner plates of maxillae 1–2 and outer plate of maxilla 2 lacking pubescence. Maxillipedal inner plate long, with distal row of several plumose setae and 4 blunt or weakly bifid naked spines, and medial row of 4 plumose setae; outer plate of medium size, with distal plumose setae, without medial row of tooth-spines, medial margin simply carved into waves; palp articles 2–3 not setose laterally, article 2 moderately setose medially, article 3 lacking organised comb row of spines near base of dactyl, apex barely produced, not rugose.

Dactyls of gnathopods with stiff setule at inner nail articulation line. Gnathopod 1 without rastellate seta on article 4. Pereopods 3–4 proportional to pereopod 5. Posterior spine sets on article 6 of pereopods 3–4 evenly spaced. Pleopods similar, peduncles with 0–1 seta; outer rami slightly shortened; basomedial setae on inner rami of pleopods bifid but not barbed; retinacula 2, accessory retinacula absent.

Posteroventral tooth of epimera 1–3 tiny, only posterior margin of epimeron 3 sparsely setulose; some epimera with sparse facial spines near ventral margin. Apicolateral corner of peduncles on uropods 1–2 with 2–1 spines, dorsal margins spinose, medial margin of uropod 2 with only one apical spine; rami of uropod 1 extending subequally, outer ramus of uropod 2 scarcely shortened, margins spinose, uropod 1 bearing basofacial spine; only inner rami of uropods 1–2 with 2 spine rows. Medial setae of outer ramus on uropod 3 absent; without subdistal peduncular spine. Ventrodistal spine on urosomite 1 at base of uropod 1 absent.

**Sexual dimorphism.** No secondary differences.

**Relationships.** In the absence of calceoli and sternal gills and the apical position of the ordinary telsonic penicillate setules, we presume this genus has its closest relationship with melitoids. It keys out very close to the *Abludomelita* – *Melita* complex, a pan-tropical marine supergenus, but differs from that taxon in the loss of one article on the mandibular palp, a scarce difference, but, more importantly, lacks inner lobes on the lower lip and therefore belongs with the hadziids (see Barnard & Barnard, 1983).

In the hadziid group, this genus appears to have its closest affinities to *Psammoniphargus*. The two genera have strong (perhaps convergent?) resemblances in the structure of the outer plate on the maxilliped and slightly less striking in the condition of the gnathopods, coxae, uropods and epimera. Our new genus differs significantly in the symmetry of the palps of maxilla 1 and subordinately in the slightly better developed mandibular palp.

We are inclined to believe that *Psammoniphargus* and *Brachina* are convergent Indo-Pacific genera descendant from the melitoid facies by loss of inner lobes on the lower lip. Except for this loss and the reduction of the mandibular palp these genera appear strongly melitoid.

The lack of calceoli and sternal gills and the presence of a basofacial spine on uropod 1 suggest a marine origin for the two derivatives.

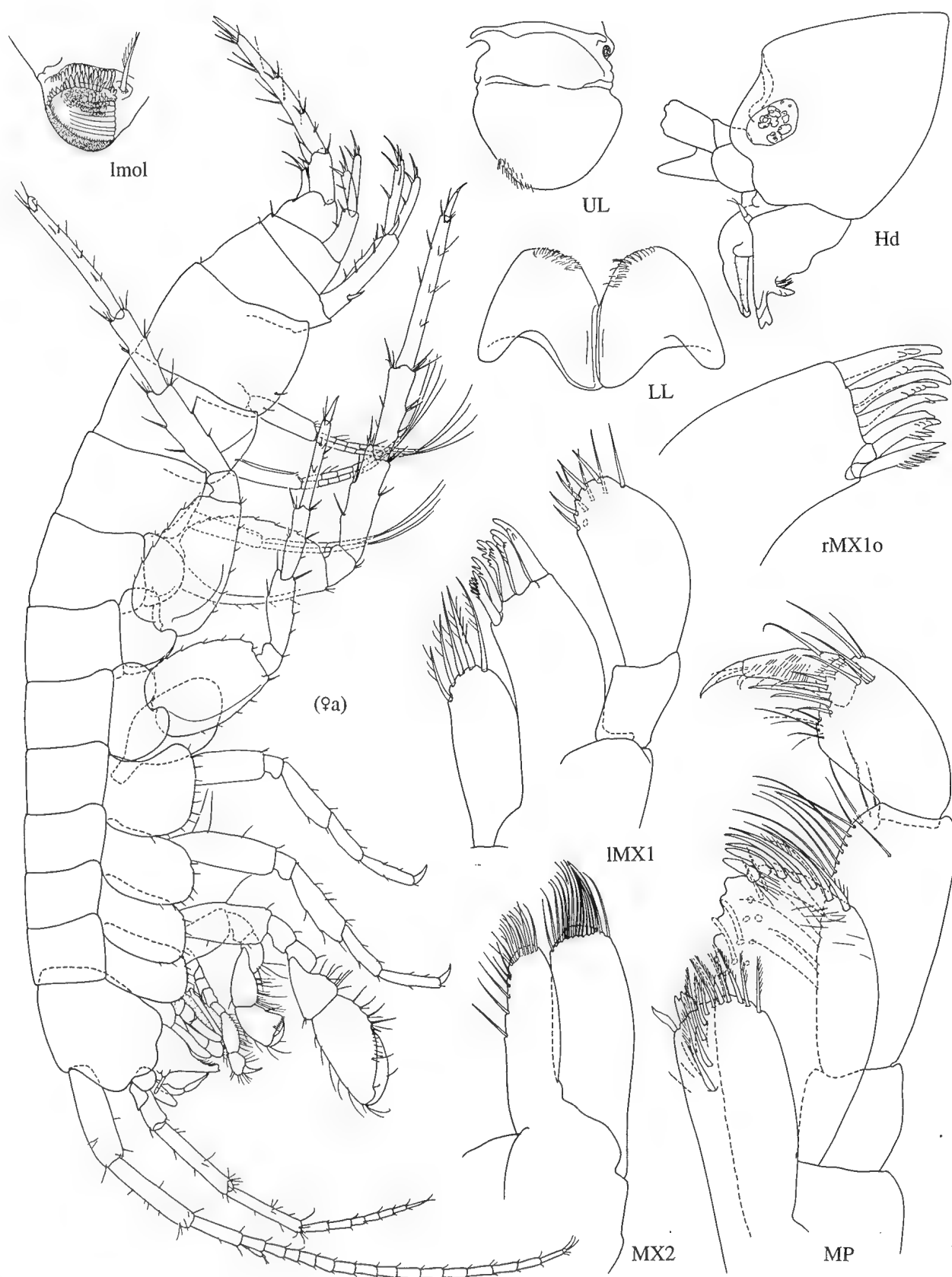


Fig. 21. *Brachina invasa* n.sp., holotype, female "y" 5.83 mm (all drawings except those indicated); female "a" 4.09 mm.



specimens. Brachina Creek, near Aroona turnoff, Flinders Ranges, South Australia, 3 March 1979, sample number 1073 (P44083), W.D. Williams collector, 7 specimens.

**Diagnosis.** As in the genus.

**Description of holotype (female "y").** *Body:* pleon (Fig. 23) poorly armed dorsally, armament bilateral, total dorsal setae on pleonites 1–6 = 2-2-2-2-0-0, spinules on pleonites 4–6 = 0-2-0; length, 5.83 mm.

*Head* (Fig. 21): rostrum obsolescent; cephalic lobes weak, founded (illustrated) or weakly subangular, eyes in death absent.

*First antenna:* length 0.62 of body, 1.6 second antenna, flagellum longer than peduncle, peduncular articles 1–2 longest, article 3 shortest, setae sparse, distoventral corner of article 1 with strong spine, flagellum with 21 articles, lacking conspicuous aesthetascs; accessory flagellum 3-articulate, scarcely exceeding apex of article 1 of primary flagellum, articles uniform after first 4, sparsely setulate. *Second antenna:* length 0.4 body; peduncle longer than flagellum, article 4 slightly longer than 5, articles 3, 4 and 5 with poor ventral setation; flagellum 10-articulate, poorly setose ventrally, lacking calceoli.

*Upper lip* (Fig. 21): apical margin evenly rounded, connection to epistome and epistome itself symmetrical, epistome with anterior keel. *Lower lip* (Fig. 21): inner lobes absent. *Left mandible* (Figs 21–23): palp article 2 with 2 apical setae, article 3 absent; incisor 5+ toothed, lacinia mobilis 4-toothed, 3 setose accessory blades; molar bearing plumose seta, several combed or brushy basal setae, other pubescence. *Right mandible* (Fig. 22): incisor 5-toothed; lacinia mobilis bifid, narrow, denticulate; accessory blades of 3 plumose spines. *Left first maxilla* (Fig. 21): palp article 2 with 5 thin apical spines and 4 subterminal facial or apicolateral setae, outer plate with 7 spines, most denticulate; inner plate with 5 apical setae. *Right first maxilla* (Fig. 21): palp symmetrical with left first maxilla; outer plate with 8 (aberrant) spines. *Second maxilla* (Fig. 21): outer plate outer apical margin without spinule, apicomedial margin of inner plate with 6 marginal thick setae. *Maxilliped* (Figs 21, 22): palp article 3 lacking setae on inner edge, no lateral setae, face with linear row of 3 setae, apex not strongly produced, not rugose; inner plate (Fig. 22) with 4 thick spines and several plumose setae apically, medial row of 4 plumose setae, and 1 ventrofacial spine.

*First gnathopod* (Fig. 22): coxal plate with 9 short setules anteriorly and apically, no posteroventral setule; article 4 without posterior hump; carpus slightly elongate, not lobate; propodus subrectangular (trapezoidal), longer than wide, posterolateral angle rounded and weakly bulbous, posterior edge with 1 acclivity and 1 set of setae, with 2 medial and 3 lateral spines (in the way we interpret these spines compared to other species other species in our work), lateral spines slightly elongate, palm transverse, convex, minutely serrate; dactylus reaching end of palm. *Second gnathopod* (Fig. 22): much enlarged; article 5 short and weakly lobate,

article 6 almond-shaped, palm oblique, palmar corner with 1 lateral hadziid seta (see Barnard & Barnard, 1983) and 2 mediofacial spines, posterior margin with 3 setose acclivities, setae of hadziid or eriopisellid form; dactyl strongly curved, fitting palm; coxal plate with 10 setules.

*Pereopods* (Figs 22, 23): coxa 3 with 9 anteroapical setules, coxa 4 emarginate, with 10 anteroventral setules and 1 posteroventral setule; pereopods 3–4 longer than gnathopod 2, pereopod 3 longer than 4, articles 4–5 weakly setose posteriorly, posterior spine formula on article 6 = 2-2-2-2 and 2-2-2-2; pereopods 5–7 similar, but progressively longer, each with 2 locking spines; coxae 5–6 bearing setule on posteroventral margin of posterior lobes, on pereopod 5 article 2 weakly expanded and minutely lobate posteroventrally, no lobe on pereopods 6–7, bearing thin short posterior setae in serration notches; dactyls of pereopods 3–7 with one facial setule at nail margin plus 2 setules more marginally. Gills of coxae 2–6 paddle-shaped, weakly pediculate, of pereopod 6 reduced, about half as long and one quarter as voluminous as gill 4, gill sizes progressively small in order: 4, 3, 2, 5, 6. Oostegites slender but lacking setae.

*Sternal (gills) processes:* None.

*Epimera* (Fig. 23): each epimeron with small posteroventral tooth, posterior margins weakly convex, with 1-1-4 posterior setules, epimeron 1 naked below, epimera 2–3 with facial spine formula of 1-2. *Pleon* (Fig. 23): each dorsolateral posterior margin of pleonites 1–3 with following setal formula, 1-1-1, pleonites 4–6 with dorsolateral spine formula of 0-1-0. Uropod 3 strongly extending beyond uropods 1 and 2 in entire animal, uropod lengths relative to uropod 1: uropod 2 = 0.60, 3 = 1.3. *Pleopods:* retinacula 2 per pleopod, no accessories; peduncles of 1-3 with 1 lateral, 1 basal and no other setae, outer rami shorter than inner by length of 2 inner articles, outer with 9-9-9 articles, inner with 8-8-8 articles, setae on basal articles = 4-1-1-4, 3-1-1-3, 2-1-1-3, bifid basomedial setae on inner rami = 3-2-2 (of the total of 4-3--3 setae present on basal article).

*First uropod* (Fig. 23): peduncle length 1.4 rami; 1 large basofacial spine on outer face; outer margin with 2 apicodistal spines besides row of 3 dorsal spines, with 3 spines medially; rami of subequal length, only inner ramus with 2 rows of marginal spines in formula of 2-2, each ramus with 4 apical spines. *Second uropod* (Fig. 23): peduncle about 1.0 length of inner ramus, with 3 dorsolateral spines, medial margin with one apical spine; outer ramus shorter than inner, with 2 dorsal spines, only inner with 2 rows of marginal spines in formula of 1-2, apices with 3 and 4 spines each. *Third uropod* (Fig. 23): peduncle length 0.36 outer ramus, longer than urosomite 3, with one medial spine, one dorsolateral and 2 ventrolateral spines; outer ramus proximal article with 3 lateral and 3 medial ranks of 3–4 spines each, apicolateral corner with 3 spines, apicomedial corner with 3 spines; article 2 small. *Telson* (Fig. 23):

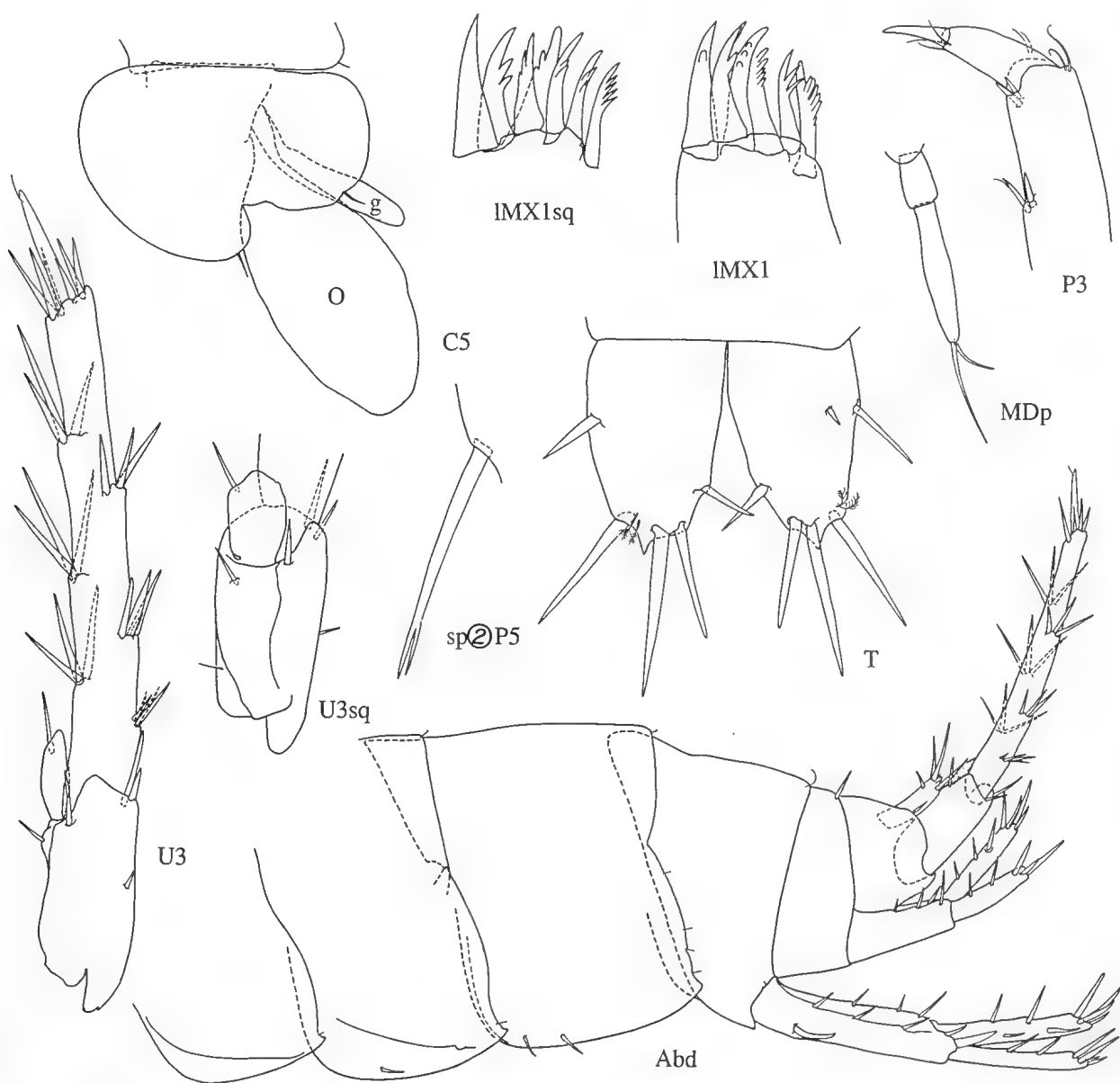


Fig. 23. *Brachina invasa* n.sp., holotype, female "y" 5.83 mm.

0.80 as long as wide, scarcely shorter than urosomite 3; cleft 100 percent of its length; apices each with spine in apicolateral notch, 2 apical spines on medial side of apical cusp, 1 apicomedial spine, 2 apicolateral penicillate setules, and each lobe with single member or pair of lateral (or partly dorsal) spines at M.37.

**Description of allotype (male "z").** *Body*: length 4.55 mm. Like female but gnathopod 2 slightly and many other body parts less setose mainly owing to slightly smaller body size or lesser maturation. Gills 2 and 3 heavily infested with surficial protozoans.

**Description of other material.** Specimen "a" (Fig. 21): female, length 4.09 mm.

Specimen "x": female, length 4.36 mm. Left mandible

with 4 rakers. Outer plate of left and right maxillae 1 with 7 spines (thus holotype aberrant).

Specimen "b": juvenile, length 2.86 mm. All taxonomic characters identifiable; examples showing lesser development than adults as follows: primary flagellum of antenna 1 with 12 articles, of antenna 2 with 6 articles; tooth on palm of gnathopod 2 rudimentary, one hadziid seta joined by 2 thin setules, posterior margin of propodus with 2 setal positions, anterior margin with 4 setal positions; posterior armament formula on article 6 of pereopod 3 = e-e-ss; article 1 of uropod 3 with 2 lateral and 3 medial spine sets; telson with only 3 apical spines on each lobe plus normal setules.

**Illustrations.** Left mandible of holotype with dotted seta



added in place where right seta present (Fig. 22); other specimens with this seta present on left mandible. Holotype selected because of completeness of all legs but bearing two aberrations: eight spines on outer plate of one maxilla 1 and lack of left molarial seta.

**Distribution.** South Australia, Flinders Ranges, in streams, springs.

### *Nedsia* n.gen.

**Etymology.** Named for the type locality.

**Type species.** *Nedsia douglasi* n.sp.

**Diagnosis.** Only pleonite 6 with 2 dorsolateral spines. Rostrum obsolescent, lateral cephalic lobes strongly projecting, very broad, no antennal sinus present. Eyes absent.

Antenna 1 elongate, longer than antenna 2, ratio of peduncular articles about 45:35:8, accessory flagellum 2-articulate. Antenna 2 very short, flagellum much shorter than peduncle, calceoli absent.

Ratio of mandibular palp articles about 5:8, only 2-articulate, article 1 not setose, article 2 linear, subtruncate, setae = 2 or 3E. Labium with inner lobes. Maxillae well setose medially, inner plate of maxilla 1 ovate, with 6 medial setae, outer plate with 7 spines, palps symmetrical, with thin apical spines. Inner plate of maxilla 2 with row of medial setae barely extending onto face apically, lacking other, medial setae.

Coxae 1–7 short, broader than long, coxae 1–4 lacking posterior spines, coxa 1 not expanded below, coxa 4 not excavate posteriorly, coxa 5 as long as 4. Gnathopods 1–2 diverse (in female, male unknown), gnathopod 1 small, feeble, carpus longer than propodus, not lobate, merus lacking hyaline lobe, palm transverse, spines not symmetrically bifid, rather with small subapical trigger-like extensions; armament at corner of palm = lateral 3 long setae, medial 4 short spines; setae along palm sparse and simple. Gnathopod 2 weakly enlarged, carpus short and lobate, hand of medium enlargement and ovate, palm oblique, irregularly spinose and sparsely setose, defining one spine.

Pereopods 5–7 moderately elongate, pereopod 7 longer than pereopods 5–6, article 2 moderately expanded, ovato-rectangular, posteroventrally extended but not lobate; dactyls of pereopods 3–7 lacking accessory spinules.

Coxae 2–6 each with flask-shaped gill, gill 6 not reduced. Thoracic segments lacking sternal gills, coxae 2–5 each with thin, poorly setose oostegite.

Uropod 3 strongly extended, peduncle short, outer ramus 2-articulate and huge, inner ramus short and scale-like, reaching to M.24 on article 1 of outer ramus. Telson longer than broad, cleft 100 percent, lobes weakly convex laterally, with subapical setation, with lateral setal-spines and single lateral penicillate setules about M.60 on each side.

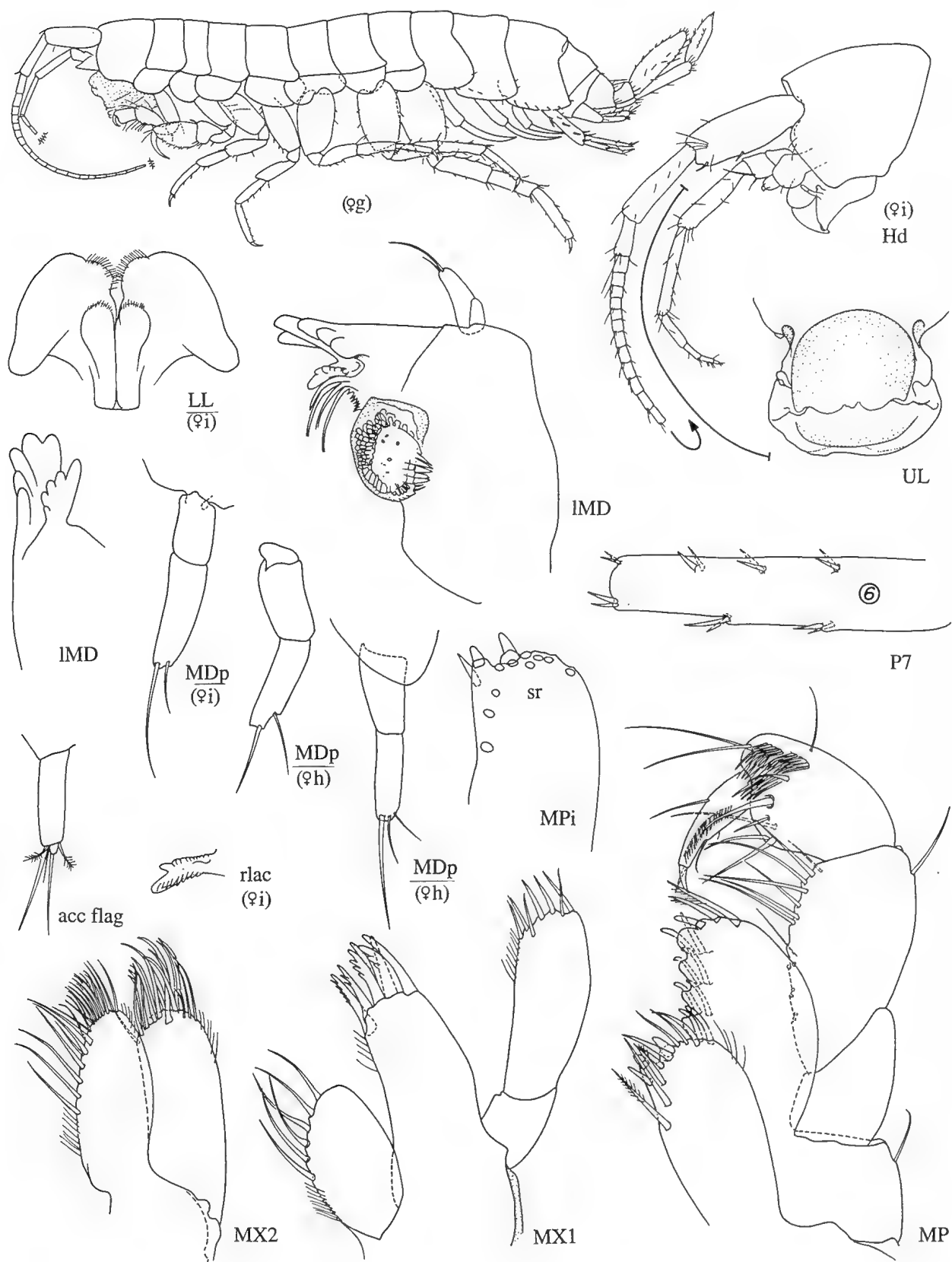
**Additional description.** Upper lip asymmetrical, weakly excavate below. Accessory blades (rakers) on mandibles very few (3–4), on right side with or without interraker plumose seta between each main raker; on both mandibles few additional serrations beyond rakers. Both plates of maxilla 2 with apical setae of medium length; inner plates of maxillae 1–2 and medial and lateral margins of maxilla 2 poorly covered with pubescence. Maxillipedal inner plate long, with distal row of several plumose setae and 2 blunt naked spines, and short medial row of plumose setae; outer plate large, with few distal plumose setae continuous with blunt naked tooth-spine, medial margin carved into sinuities, spineless, ventral margin with pairs of blunt setae; palp articles 2–3 weakly setose 2 laterally, article 2 moderately setose medially, article 3 with comb rows near base of dactyl, apex weakly produced, dactyl unguiform, with short nail. Dactyls of gnathopods lacking inner tooth-spine, lacking nail. Gnathopod 1 without rastellate seta of article 4. Pereopods 3–4 of proportions similar to pereopods 5–7. Posterior spine sets on article 6 of pereopods 3–4 unevenly spaced. Pleopods similar, peduncles with only 1 seta each; rami extending subequally; basomedial setae on inner rami of pleopods not bifid; retinacula 2, one accessory retinaculum present. Posteroventral tooth of epimera 1–3 absent, posterior margins smooth and barely setulose; some epimera with facial spines near ventral margin. Apicolateral corner of peduncles on uropods 1–2 with 1 and 2 spines (thus with 0–1 ventrally displaced spines), dorsal margins spinose, medial margin of uropod 1 with 2 apical spines; rami of uropod 1 extending subequally, outer ramus of uropod 2 shortened; uropod 1 with basofacial spine; all rami of uropods 1–2 with 2 spine rows, albeit weakly furnished. Medial setae of outer ramus on uropod 3 sparse; usually with subdistal peduncular seta(e) or spine(s). Ventrodistal spine on urosomite 1 at base of uropod 1 absent.

**Sexual dimorphism.** Only female known.

**Aberrance.** Left uropod 3 of holotype regenerant, lacking article 2. Most other specimens lacking uropod 3 and pereopods 5–7 through breakage during preservation.

**Variables.** Interraker setae on mandibles present or absent; setules similar to interrakers occasionally affixed beyond rakers.

**Relationship.** This genus is probably an invader from the sea rather than a member of the crangonyctoid facies because the apical article 2 on the accessory flagellum is shortened, a mediobasal spine is present on article 1 of antenna 1, the lower lip has inner lobes, the mandibular palp is reduced, the inner plate of the maxilliped has only two apical spines, the outer plate has its medial spines replaced by wavy cusps and the sternal gills are absent (but see *Antipodeus* in Williams & Barnard, 1988).



**Fig. 24.** *Nedsia douglasi* n.sp., holotype, female "g" 4.77 mm (all drawings except those indicated); female "h" 5.08 mm; female "i" 4.38 mm.

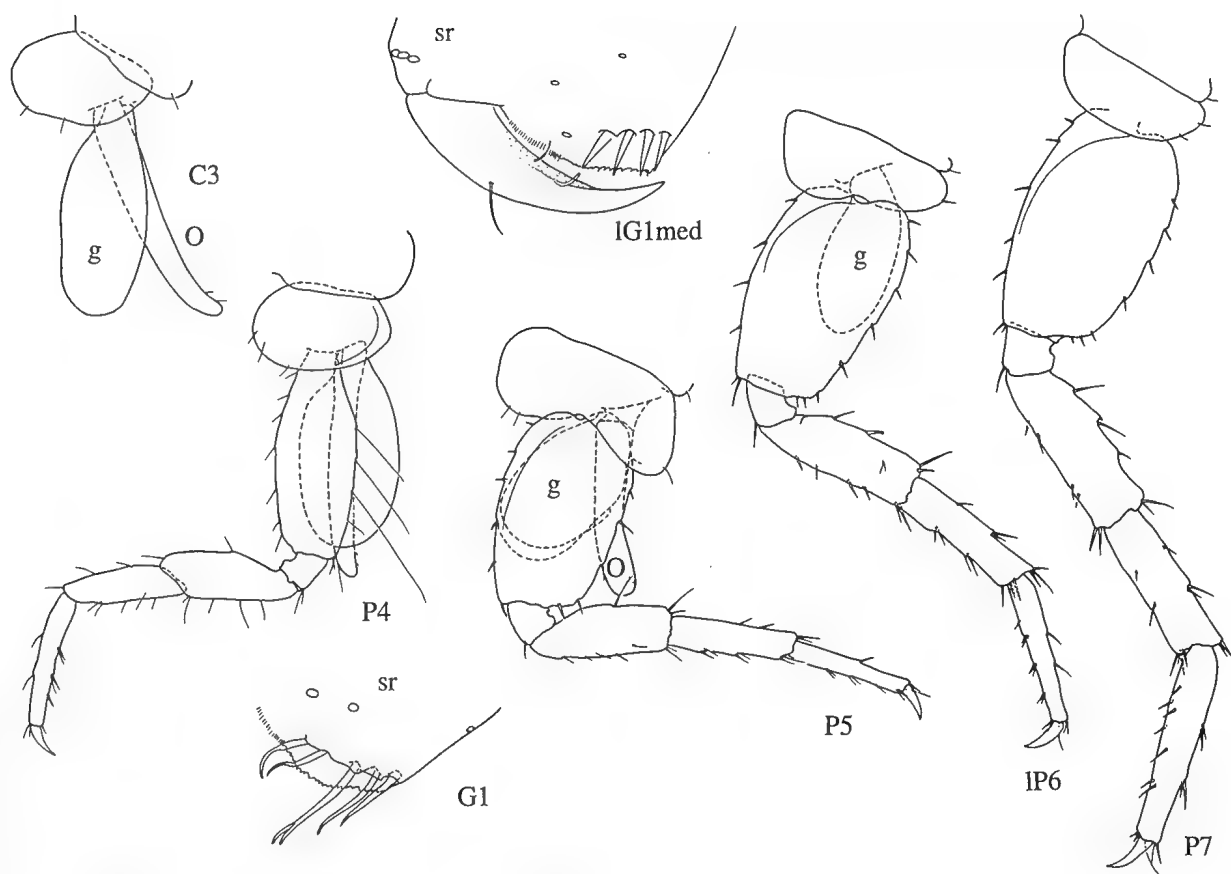


Fig. 25. *Nedsia douglasi* n.sp., holotype, female "g" 4.77 mm.

*Nedsia douglasi* n.sp.

Figs 24–26

**Etymology.** Named for the collector of the material.

**Type locality.** Ned's Well, Yardie Creek, North West Cape, Western Australia.

**Material examined.** HOLOTYPE (Western Australian Museum, WAM 7-64), female "g" 4.77 mm, in the type series collected August 1963, A.M. Douglas collector. Other material from type series (PARATYPES), female "h" 5.08 mm, female "i" 4.38 mm and 26 other specimens (no males).

**Diagnosis.** As in the genus.

**Description of holotype (female "g").** Body (Fig. 24): urosome poorly armed dorsally; length, 4.74 mm.

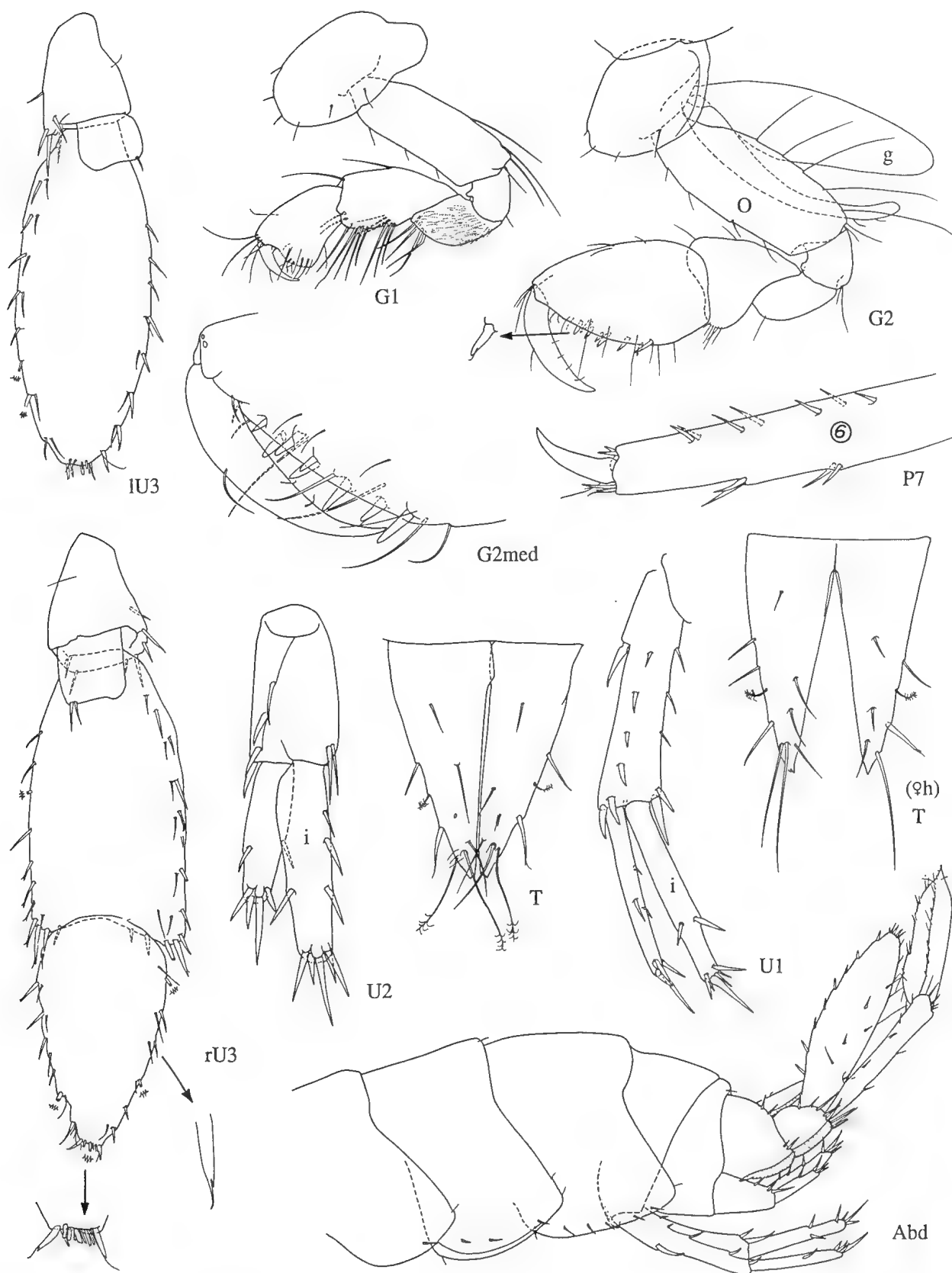
**Head** (Fig. 24): rostrum obsolescent; eyes absent.

**First antenna** (Fig. 24): length about 0.6 of body (broken), 2.4 second antenna, flagellum longer than peduncle, peduncular article 1 longest, article 3 shortest, setae sparse, flagellum with many articles, no calceoli, no aesthetascs; accessory flagellum 2-articulate, second article tiny, articles of primary flagellum uniform, sparsely setulate. **Second antenna** (Fig. 24): length 0.25

body; peduncle longer than flagellum, articles 4–5 equally long; articles 3, 4 and 5 with weak ventral setation, article 3 without dorsomedial spines; flagellum 4-articulate, lacking calceoli.

**Upper lip** (Fig. 24): apical margin excavate, connection to epistome and bulbous epistome itself slightly asymmetrical. **Left mandible** (Fig. 24): palp article 1 shorter than 2, article 2 with 2 apical setae; incisor 5-toothed, lacinia mobilis 5-toothed, 4 setose accessory blades; molar lacking distal plumose seta, no other pubescence. **Right mandible**: incisor 5-toothed; lacinia mobilis bifid, slender, each flake denticulate; accessory blades of 4 scarcely plumose spines. **Right and left first maxillae** (Fig. 24): palp article 2 with 7 thin apical and subapical spines, outer plate with 7 spines, most denticulate; inner plate with 6 medial setae. **Second maxilla** (Fig. 24): outer plate outer apical margin with pubescence, basomedial margin of inner plate with pubescence. **Maxilliped** (Fig. 24): palp article 3 with pair of thin setae on inner edge; inner plate with 1 ventrofacial spine.

**First gnathopod** (Figs 25, 26): coxal plate with short setae apically, without posteroventral spine; article 4 posteriorly bulbous; carpus not lobate; propodus trapezoidal, expanding apically, longer than wide, posterior edge almost naked, corner of palm almost square, with 3 lateral setae and 4 medial spines, palm



**Fig. 26.** *Nedsia douglasi* n.sp., holotype, female "g" 4.77 mm (all drawings except those indicated); female "h" 5.08 mm.

slightly convex; dactylus reaching end of palm. Palm of *second gnathopod* (Fig. 26): with 4 lateral and 4 medial spines, spine at palmar corner medial, coxal plate broader and poorly setose.

*Pereopods* (Figs 24–26): coxa 3 with similar setae, coxa 4 more irregular, with similar setae; pereopods 3–4 longer than gnathopod 2, pereopod 3 not longer than 4, articles 4–5 sparsely setose posteriorly, posterior margin of article 6 on pereopods 3–4 with armament formula of ES-ES-S-S, thus with only one locking spine; pereopods 5–7 similar but consecutively elongate, each with 2 locking spines; anterior spines on pereopod 7 article 6 displaced inward by keel-like expansion of segment; coxae 5–7 bearing few setae on ventral margin of posterior lobes, article 2 moderately expanded and not lobate but extended posteriorly, bearing thin short posterior setae; dactyls of pereopods 3–7 simple, naked except for outer basal penicillate setule. Gills of coxae 2–6 flask-shaped, of pereopod 6 not reduced. Oostegites strap-shaped, poorly setose.

*Epimera* (Fig. 26): each epimeron posteroventrally quadrate (softly), posterior margins scarcely convex, smooth and barely setulose, epimera 1–3 with 1–3–6 ventrofacial spines, lacking lateral oblique ridge. *Pleon* (Figs 24, 26): only pleonites 2 and 5 with dorsolateral posterior seta, pleonite 6 with 2 dorsolateral and 2 distoventral spinules; uropod 3 extending well beyond uropods 1 and 2 in entire animal, uropod lengths relative to uropod 1: uropod 2 = 0.5, 3 = 1.33. *Pleopods*: retinacula 2 per pleopod, one accessory: peduncles each with 1 apicolateral seta, rami extending subequally, outer with 10–9–8 articles, inner with 10–9–8 articles, setae on basal articles = 1–1–1–1 for all rami, none bifid.

*First uropod* (Fig. 26): peduncle length 1.3 rami, 1 basofacial spine, outer margin with 1 apicodistal spine besides row of 3 dorsal spines, with 2 apicomедial spines: rami of subequal length, both rami with 2 sparsely filled rows of marginal spines. *Second uropod* (Fig. 26): peduncle about 1.1 length of inner ramus, with 2 apicodorsal spines, 2 dorsolateral spines, medial margin with 2 apical spines: outer ramus shorter than inner, both with 2 rows of marginal spines in formula of 1–1 and 1–3, apices of rami on uropods 1–2 with 4–6 and 4–5 spines. *Third uropod* (Fig. 26): peduncle length 0.28 outer ramus, shorter than urosomite 3, with subdistal seta besides apicolateral cluster of 5 spines; outer ramus proximal article with several irregular spine-setal ranks, article 2 shorter but similarly armed; inner ramus length 0.12 of outer, with 2 apical spines, left uropod 3 regenerating. *Telson* (Fig. 26): 1.2 as long as wide, as long as urosomite 3; cleft 100 percent of its length; apices minutely notched, subapices each with 3 long setae, 3 other dorsal setae and 2 lateral setae on each lobe, each lobe with single penicillate setule dorsolaterally at M.60.

**Description of other material.** Specimen "h": female, length 5.08 mm. Mandibular palps (Fig. 24) with 2–3 apical setae on article 2. Telson less setose apically than holotype.

Specimen "i": female, length 4.38 mm. *Head*, right lacinia mobilis and mandibular palp illustrated (Fig. 24).

**Distribution.** Western Australia, North West Cape, in well.

**ACKNOWLEDGMENTS.** We thank the collectors of the material. Linda B. Lutz of Vicksburg, Mississippi, inked our illustrations. Marilyn J. Schotte, Elizabeth Harrison-Nelson and Paula Rothman assisted J.L.B. At the Smithsonian Institution. Miss Sandra Lawson and Robert Taaffe [deceased] of the University of Adelaide greatly assisted J.L.B. with problem-solving. Mr J. Bradbury and Mrs Kelly Fennell, of the same institution, assisted W.D.W. in checking the manuscript and labelling the drawings, respectively. Dr J.R. Holsinger made valuable comments on the draft as also did J. Bradbury and an anonymous reviewer. They are thanked. Also thanked is the Australian Biological Resources Study, Canberra, for financial support in the final stages of preparation of the manuscript.

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## Cainozoic and Recent Deep Sea Cytherurid Ostracoda from the South Western Pacific and Eastern Indian Oceans, Part I: Cytherurinae

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**ABSTRACT.** From a largely unpublished database the systematics, geographical and stratigraphical distribution of Cainozoic cytherurine Ostracoda found in the deep sea environment of the eastern Indian and south-western Pacific regions is presented. Eleven new species: *?Eucytherura anoda*, *Eucytherura batalaria*, *?Eucytherura boomeri*, *Eucytherura elegantula*, *Eucytherura indianensis*, *Eucytherura multituberculata*, *Eucytherura pacifica*, *Eucytherura parabatalaria*, *?Eucytherura polydictyota*, *Eucytherura tumida* and *Hemiparacytheridea vanharteni* are described. Five species are assigned to previously established taxa and four species are left in open nomenclature due to paucity of material.

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Deep sea ostracod studies which have examined the fine fraction (less than 250 micron aperture sieve) of samples frequently report species of the Cytheruridae. That this family comprises very small species (less than 0.40 mm in length) explains why they are poorly represented in most published faunal lists of deep sea ostracods. This study indicates that the group is well represented in the deep-sea at least in the Indo-Pacific region and that this has been so throughout the Cainozoic. The present study is concerned with the Cytherurinae. A subsequent paper will describe the Cytheropterinae.

Taxonomic knowledge of deep sea forms of the genera considered in this report, is based on material collected mainly from the Atlantic region (Maddocks &

Steineck, 1987; Whatley & Coles, 1987; Coles & Whatley, 1989). Material collected from the deep Indo-Pacific and compiled through comprehensive studies undertaken in the Micropalaeontological Research Unit, Aberystwyth, Wales, is still incorporated in largely unpublished theses. To assimilate the nomenclature contained therein with the present taxonomic study it is considered useful to list all names—unpublished as well as published—that have been applied to these taxa during the course of our work. (Unpublished references are indicated by asterisk \*). This valuable source of information, useful for improving our understanding of the systematics and zoogeography of the taxa, is the focus of this report.



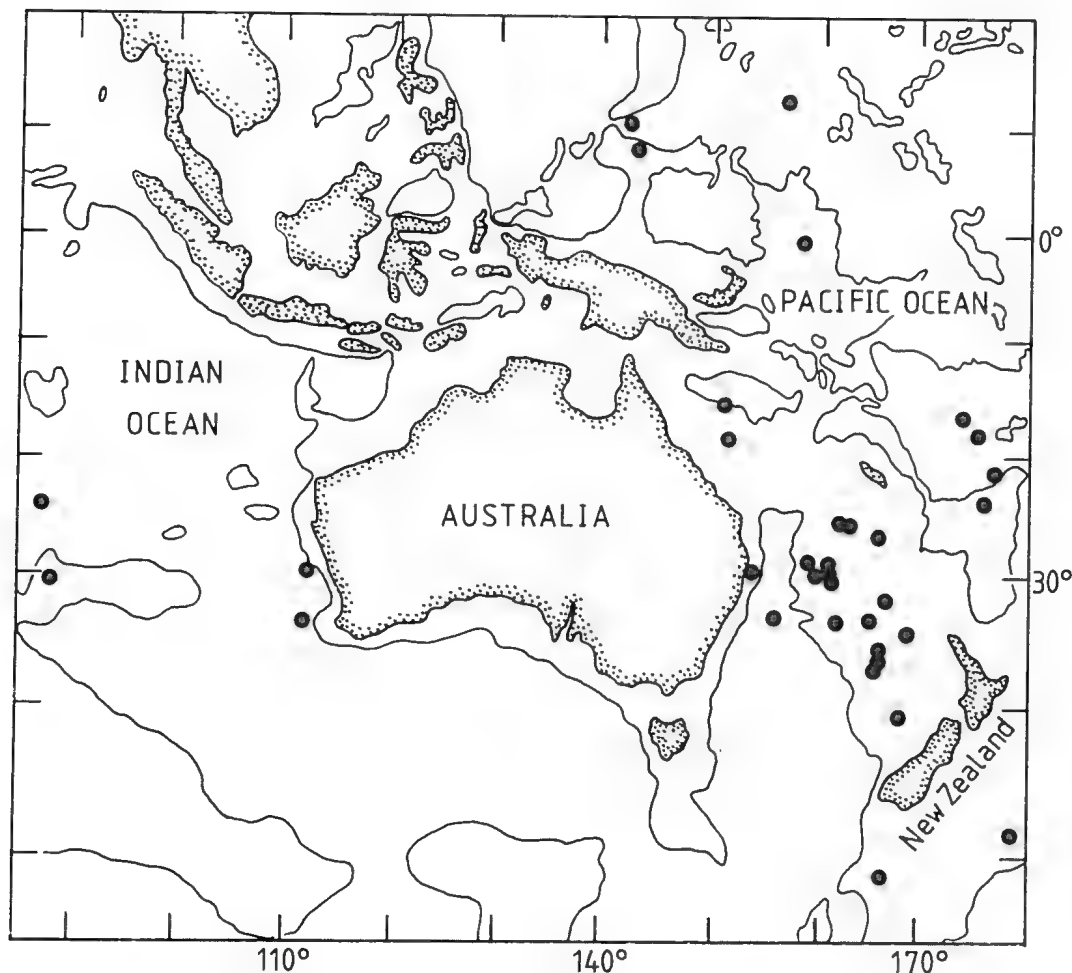


Fig. 1. Eastern Indian Ocean and Southwest Pacific site locations in which the species described in the text were found.

This study aims to formally describe hitherto unpublished cytherurine species of the genera *Eucytherura* and *Hemiparacytheridea* encountered within the bathyal and abyssal environment. Our database includes Cainozoic and Recent material from the south-western Pacific and eastern Indian Ocean regions (Fig. 1). The higher systematic affinities of cytherurine species are somewhat in flux, complicated by the erection of monospecific genera and the discovery of many new species displaying considerable morphological variation. Maddocks and Steineck (1987) proposed an emended subfamily Eucytherurinae to unite genera with solum pore clusters. We adopt a rather broad approach herein assigning all species to either *Eucytherura* or *Hemiparacytheridea* on the basis of solum pore clusters and hingetype; further we synonymise other cytherurine genera *Typhlocythere*, *Typhloeucytherura* and *Parahemingwayella* with the former and *Tuberculocythere* with the latter. This is discussed in the relevant sections below.

**Material.** Site locations from which the species described herein were recovered are shown in Fig. 1. A list of samples with their stratigraphical and geographical details is given in Table 1. The stratigraphical range of all species considered in this study is shown in Table 2. Most type and figured specimens were selected from the collections at the Micropalaeontological Research Unit, Aberystwyth, Wales. The types and some figured specimens from this material have been deposited at the British Museum of Natural History, London; the registration numbers prefixed OS apply to these. Other figured specimens remain in Aberystwyth and are catalogued with numbers prefixed MA or SD. Type and figured specimens not chosen from the Aberystwyth collections have been deposited at the Australian Museum, Sydney and are catalogued with numbers prefixed AMF.

## Systematic Palaeontology

## Cytherurinae Müller, 1894

*Eucytherura* Müller, 1894

**Type species.** *Cythere complexa* Brady, 1867.

**Emended Diagnosis.** A genus of the subfamily Cytherurinae with a small carapace of subrectangular, quadrate or subtriangular lateral outline. Ventral margin gently sinuous, often obscured by posteroventral tumidity or tubercle. Eye tubercle present or absent. Surface very ornate with reticulation, tubercles and ridges. Normal pore canals usually of two types: those emergent through mural pore conuli; and those arranged in groups through the solum of the reticulation. Muscle scars consist of four subovate adductor scars in a vertical row and a subreniform frontal scar ahead of the row. Hinge, in right valve, consists of a small but prominent circular or ovate tooth on anterior and posterior ends, with a finely locellate median groove very narrow at mid-length and often flexured or sinuous.

**Comparisons.** Our concept of *Eucytherura* indicated in the above emended diagnosis allows us to

synonymise *Typhlocythere* Bonaduce, Ciampo & Masoli, 1975, *Typhloeucytherura* Colalongo & Pasini, 1980 and *Parahemingwayella* Dingle, 1984. These three genera were proposed mainly to accommodate the fact that they differ from *Eucytherura* (as presently diagnosed by Weingeist, 1949) in lacking eyes. Deep sea taxa always lack eyes as a result of living in an aphotic environment. Consequently, this feature cannot be used to recognise genera in the deep sea. It may well be that blindness of these genera in shallow environments had preadapted them for deeper water existence, but we can find no consistent features which might reveal their separate generic identity. Previous workers have stressed the importance of certain features for generic identification such as inflation and outline, absence of dorsal ridges or tubercles and nature of ornament. We recognise these features as being variable in number or nature, and moreover, as occurring in variable combination in different species. For this reason, we prefer to retain species previously assigned to *Parahemingwayella*, *Typhlocythere* and *Typhloeucytherura* within *Eucytherura*. The latter genus can be separated from *Hemiparacytheridea* by virtue of its hingement, having a distinct ovate posterior terminal element, and its solum pore clusters.

Key to Deep-sea Species of *Eucytherura*

1. Solum pore clusters present ..... 4
  - Normal pores large and regularly distributed, valve size small ..... 2
2. Weakly inflated; ornament predominantly reticulation ..... *E. anoda*
  - Moderately well inflated; ornament of ridges and reticulation ..... 3
3. Alate; subcentral tubercle present; surface ridges distinct ..... *E. polydictyota*
  - Not alate; subcentral tubercle absent; surface ridges diffuse ..... *E. boomeri*
4. Lateral outline subtriangular ..... 5
  - Lateral outline subrhomboidal, subquadrate or subrectangular ..... 8
5. Bituberculate ventrally; surface not strongly spinose ..... 6
  - Single posteroventral swelling; surface strongly spinose ..... *E. elegantula*
6. Subcentral tubercle high on lateral surface; deep concavity in dorsal margin ..... *Eucytherura* sp. 3
  - Posterodorsal tubercle or ridge present; strong anterior marginal rim ..... 7
  - Posterodorsal tubercle or ridge absent; weak anterior marginal rim ..... *E. batariala*

7. Dorsal margin sinuous; reticulation well developed with extensive ventral microreticulation..... *E. parabatalaria*
- Dorsal margin gently convex; reticulation relatively irregular with only poorly developed ventral microreticulation..... *E. downingae*
8. Strongly tuberculate..... *E. multituberculate*
- Tubercles not well developed or absent..... 9
9. Caudal process well developed ..... *Eucytherura* sp. 1
- Caudal process short or absent ..... 10
10. Carapace tumid, often spinose ..... 11
- Carapace moderately inflated, may have intrafossal spines ..... 13
11. Reticulation spinose; short horizontal median ridge present ..... 12
- Reticulation lacks spines; median ridge absent ..... *E. tumida*
12. Lateral spines weakly developed; microreticulation present on anteroventral surface ..... *E. indianensis*
- Strongly spinose; ventral microreticulation absent..... *E. calabra*
13. Lateral outline rhomboidal..... *E. pacifica*
- Lateral outline quadrate to rectangular ..... 14
14. Large bulbous posteroventral swelling; lacks a median ridge..... *Eucytherura* sp. 2
- Posteroventral tubercle moderately swollen; median oblique ridge present..... 15
15. Fossal spines present ..... *E. pseudoantipodum*
- Fossal spines absent..... *Eucytherura* sp. aff. *antipodum*

**?*Eucytherura anoda* n.sp.**

Fig. 2 E–G

**Etymology.** Latin, without swellings. Referring to the lack of nodosity of this species.

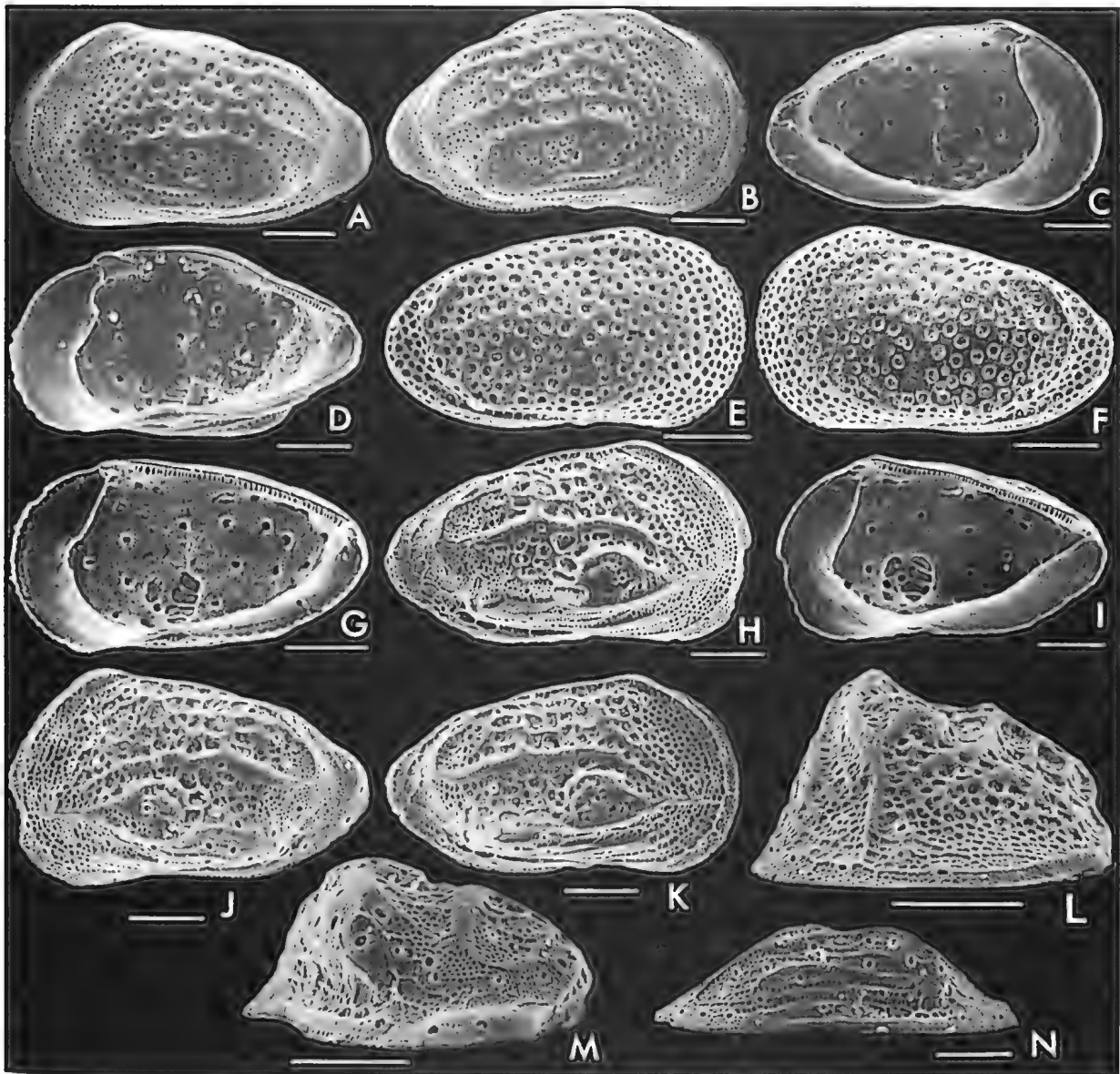
**Type material and dimensions.** Holotype, AMF 91143, adult right valve, length 0.20 mm, height 0.11 mm. Paratype: AMF 91144, adult left valve, length 0.22 mm, height 0.12 mm. Both specimens are from the type locality and horizon.

**Type locality and horizon.** Central Lord Howe Rise, present day water depth 1416 m, OSI cruise 12-87, core 13GC10, coretop, Recent.

**Diagnosis.** ?*Eucytherura* with weakly inflated, well-rounded, elongate ovate carapace. Surface coarsely

reticulate, fossae circular diminishing in size distally; anteriorly muri are concentrically aligned parallel to anterior margin. Arcuate ridge posterodorsally. Median hinge element slightly convex.

**Description.** Very small, subovate in lateral view. Anterior margin symmetrically convex; posterior margin strongly convex, apex at mid-height. Dorsal margin slightly undulating, gently sloping posteriorly. Ventral margin gently biconvex. Weakly calcified and weakly inflated, posteroventral margin compressed. Arcuate ridge posterodorsally. Surface coarsely reticulate, fossae circular, diminishing in size and increasing in density towards the free margins; anteriorly muri are concentrically aligned parallel to anterior margin. Adductor muscle scars large, four in a subvertical row anteroventral of valve centre, frontal scar subreniform, just ahead of dorso-median adductor scar; normal pores, simple and well distributed,



**Fig. 2.** Scanning electron micrographs. All scale bars are 50  $\mu\text{m}$ . **A–D**, *?Eucytherura boomeri* n.sp., **A**, external lateral view of adult left valve (holotype, AMF 91141), Late Pleistocene, **B**, external lateral view of adult right valve (AMF 91142), Late Pleistocene, **C**, internal view of holotype (AMF 91141), **D**, internal view of paratype (AMF 91142); **E–G**, *?Eucytherura anoda* n.sp., **E**, external lateral view of adult right valve (holotype, AMF 91143), Late Pleistocene, **F**, external lateral view of adult left valve (AMF 91144), Late Pleistocene, **G**, internal view of holotype (AMF 91143); **H–N**, *?Eucytherura polydictyota* n.sp., **H**, external lateral view of adult right valve (AMF 91145), Late Pleistocene, **I**, internal view of same specimen, **J**, external lateral view of adult left valve (AMF 91147), Late Pleistocene, **K**, external lateral view of adult right valve (holotype, AMF 91146), Late Pleistocene, **L**, anterior view of same specimen, **M**, posterior view of same specimen, **N**, ventral view of same specimen.

internally emergent at base of large pits. Antimerodont hinge: finely crenulate median element; in RV, terminal elements finely denticulate, narrow and elongate, tapering under ends of median element. Inner lamella moderately broad anteriorly, with small crescentic vestibulum, narrow ventrally with narrow vestibulum. Few radial pore canals, 4–5 true anteriorly, 3 posteroventrally.

**Comparisons.** Differs considerably from the other species of the genus in its more uniform reticulation with circular fossae and weaker inflation. It lacks normal pore clusters and for this reason is only tentatively placed in *Eucytherura*.

**Distribution.** Known only from the type locality and horizon.

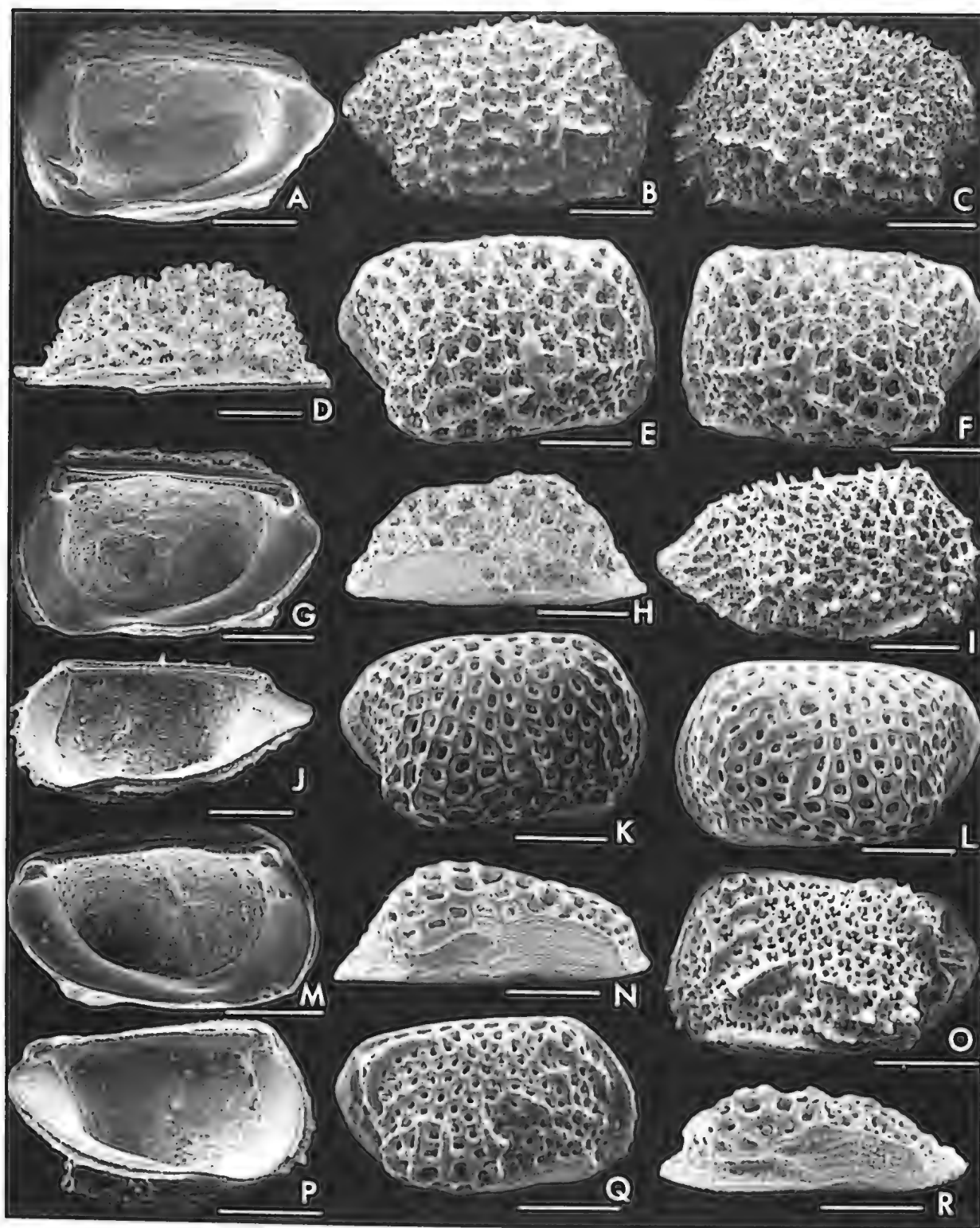


Fig. 3. Scanning electron micrographs. All scale bars are 100  $\mu$ m. A–D, *Eucytherura calabra* (Colalongo & Pasini), A, internal view of adult right valve (MA/IP/414) from DSDP Site 209, core 2, section 2, Early Pleistocene, B, external lateral view of same specimen, C, external lateral view of adult left valve (MA/IP/413) from DSDP Site 209, core 1, section 5, Early Pleistocene, D, ventral view of same specimen; E–H, *Eucytherura indianensis* n.sp., E, external lateral view of adult right valve (OS 14069), Pleistocene, F, external lateral view of adult left valve (holotype, OS 14068), Pleistocene, G, internal view of adult right valve (OS 14069), Early Pleistocene, H, ventral view of holotype (OS 14068); I–J, *Eucytherura* sp. 1, I, external lateral view of adult right valve (MA/IP/421) from DSDP Site 289, core 3, section

*Eucytherura* aff. *antipodum* Neale, 1975

Fig. 3 Q–R

"*Eucytherura* sp. 8" Ayress, 1988\*: 624; pl. 22, figs 7–9.

**Dimensions.** Adult right valve, MA/IP/426, length 0.31 mm, height 0.13 mm.

**Diagnosis.** Subrectangular and weakly inflated. Surface reticulate, fossae well rounded, muri thickened over posteroventral tubercle which overhangs ventral margin. Strong crescentic rib extends close to margin posterodorsally and a short oblique rib is present subcentrally. Ventral surface microreticulate.

**Comparisons.** The single specimen found in this study has strong affinities with *E. antipodum* Neale recorded in the Late Cretaceous Gingin Chalk of western Australia and clearly is closely related to it. The specimen differs from that species only in having weaker anterodorsal and subcentral tubercles and lacking fossal infillings. It is also very similar to *E. pseudoantipodum* Coles & Whatley, differing from that species in its more elongate lateral outline, its thickened muri on the posteroventral tubercle and lack of fossal spines.

**Distribution.** So far this species has been recorded only in the Pleistocene of DSDP Site 254, at the southern limit of the Ninetyeast Ridge, Indian Ocean.

*Eucytherura batalaria* n.sp.

Fig. 4 A–D

"*Eucytherura batalaria*" Downing, 1985\*: 448, pl. 19, figs 19,20.–Ayress, 1988\* (in part), p. 582, pl. 20, figs 1–4.

**Etymology.** Latin, a warship armed with battering ram. Referring to the resemblance of the anterior marginal spine to a battering ram.

**Type material and dimensions.** Holotype, OS 14080, adult right valve, length 0.35 mm, height 0.20 mm. Paratypes: OS 14081, adult left valve, length 0.35 mm, height 0.20 mm, Site 209, core 2, section 2, interval 75–80 cm, Early Pleistocene, Zone NN 19; OS 14082, adult left valve, length 0.28 mm, height 0.18 mm, Site

207A, core 1, section 4, interval 8–17 cm, Early Pliocene, Zone NN 13.

**Type locality and horizon.** Lord Howe Rise, present day water depth 1428 m, DSDP Site 209, core 2, section 6, interval 75–80 cm, Early Pleistocene, Zone NN 19.

**Diagnosis.** A subtriangular to subovate species of *Eucytherura* with a long marginal spine at mid-height anteriorly, lacking tubercles or ridges dorsally and a narrow anterior marginal rim. Primarily and secondarily reticulate.

**Description.** Small, subtriangular to subovate in lateral view. Anterior margin bluntly convex, weakly rimmed with three prominent denticles: the uppermost at mid-height longest, the lower two projecting downward. Posterior margin very short with a prominent spine at ventral and dorsal angle. Dorsal margin weakly convex usually interrupted by short spines, one prominent just behind mid-length. Ventral margin gently convex with very weak oral incurvature. Thin-shelled and weakly inflated. Tuberculate ventrally: sub-central tubercle subhemispherical bearing horizontal ridge; posterior tubercle longitudinally elongate bearing a row of at least three prominent spines. Vento-lateral ridge extends from anteroventral margin below ventral tubercles. Lateral surface covered with polygonal primary and secondary reticulation; primary muri have slightly raised conjunctions, primary fossae subdivided usually into three secondary fossae over most of the valve surface but more numerous towards the valve periphery. Microreticulate anteroventrally and on the posteroventral periphery. Internal surface with clusters of 4 to 5 perforations. Other internal features as for genus.

**Comparisons.** The close similarity of this species to *Eucytherura downingae* (Coles & Whatley) clearly indicates a close relationship with that species. *Eucytherura batalaria* can be distinguished by its lack of a posterodorsal tubercle or ridge, its very weakly developed anterior rim and more rugose ornament.

**Distribution.** Found so far only in the south-west Pacific region, viz: Early Miocene of DSDP Site 593; Middle Miocene and Pleistocene of DSDP Site 209; Middle Miocene of DSDP Site 56; Middle to Late Miocene of DSDP Site 592; Pliocene of DSDP Sites 207A and 208; Late Pleistocene of cores Z2108, Sonne 36–61 and 1–86/6GC3; Recent (coretop) of OSI core 12–87/13GC10.

4, Early Pleistocene, J, internal view of same specimen; K–N, *Eucytherura tumida* n.sp., K, external lateral view of adult right valve (holotype, OS 14074), Pleistocene, L, external lateral view of adult left valve (OS 10), Pleistocene, M, internal view of adult left valve (OS 14076), Early Pleistocene, N, ventral view of holotype (OS 14074) Pleistocene; O–P, *Eucytherura pseudoantipodum* Coles & Whatley, O, external lateral view of adult left valve (MA/IP/423) from DSDP Site 209, core 1, section 1, Late Pleistocene, P, internal view of adult right valve (MA/IP/424) from DSDP Site 209, core 1, section 1, Late Pleistocene; Q–R, *Eucytherura* aff. *antipodum* Neale, Q, external lateral view of adult right valve (MA/IP/426) from DSDP Site 254, core 1, section 3, Early Pleistocene, R, internal view of same specimen.



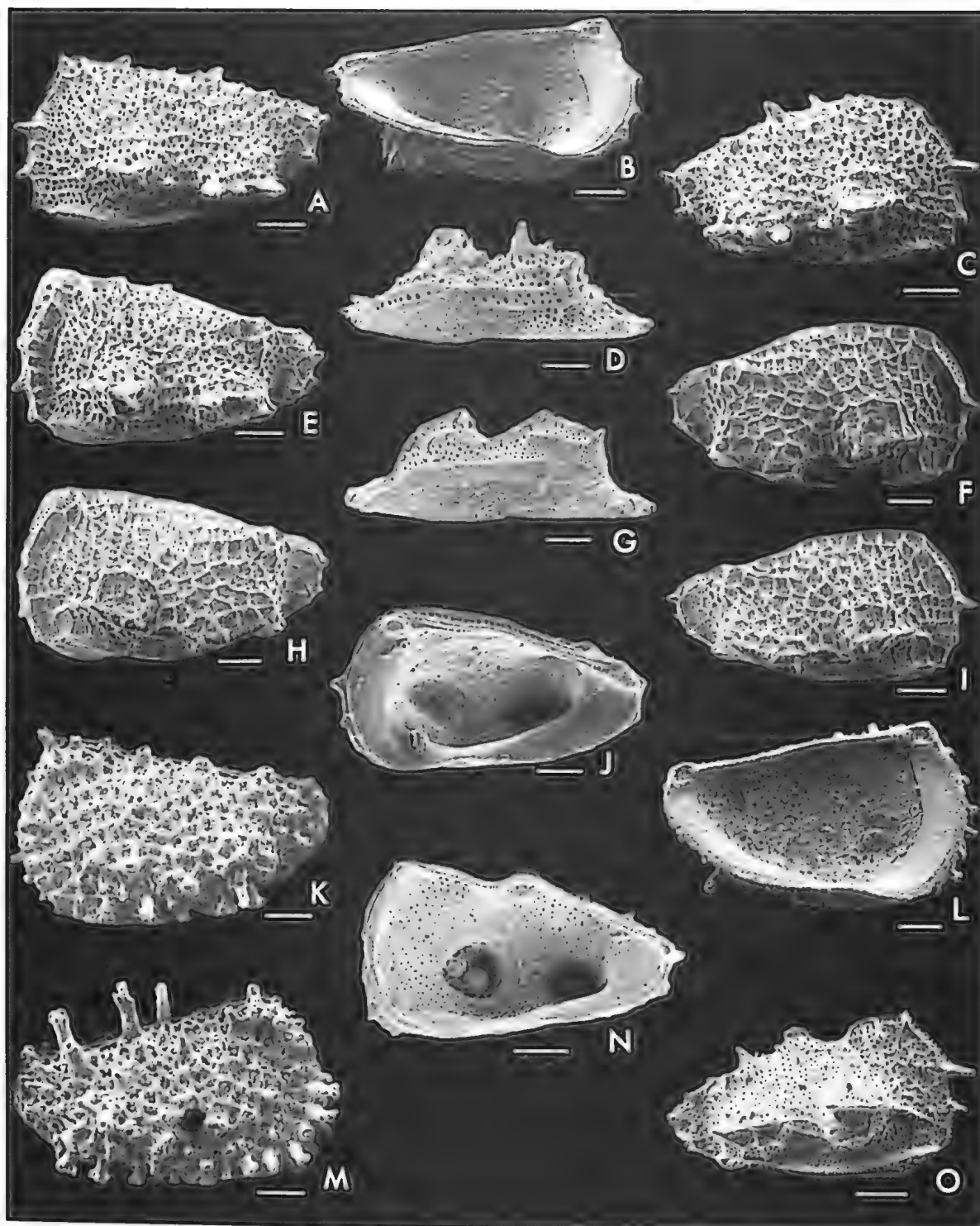


Fig. 4. Scanning electron micrographs. All scale bars are 50  $\mu$ m. A–D, *Eucytherura batallaria* n.sp., A, external lateral view of adult left valve (OS 14081) Early Pleistocene, B, internal view of adult left valve (MA/IP/393) from DSDP Site 209, core 1, section 1, Late Pleistocene, C, external lateral view of adult right valve (SD/WPP/342) from DSDP Site 208, core 9, section 5, Early Pliocene, D, ventral view of paratype (OS 14081); E, *Eucytherura downingae* (Coles & Whatley), external lateral view of adult left valve (MA/IP/392) from DSDP Site 209, core 1, section 5, Early Pleistocene; F–J, *Eucytherura parabatalaria* n.sp., F, external lateral view of adult right valve (holotype, OS 14083), Early Pleistocene, G, ventral view of adult left valve (OS 14084), Early Pleistocene, H, external lateral view of same specimen, I, external lateral view of adult right valve (OS 14085), Early Pleistocene, J, internal view of adult right valve (MA/IP/397) from DSDP Site 254, core 1, section 2, Pleistocene; K–M, *Eucytherura elegantula*



*?Eucytherura boomeri* n.sp.

Fig. 2 A–D

**Etymology.** For Dr Ian Boomer in recognition of his innovative work on deep-sea Ostracoda.

**Type material and dimensions.** Holotype, AMF 91141, adult left valve, length 0.25 mm, height 0.12 mm. Paratype: AMF 91142, adult right valve, length 0.24 mm, height 0.13 mm. Both specimens are from the type locality and horizon.

**Type locality and horizon.** Western flank of Lord Howe Rise, present day water depth 1340 m, Sonne core 36–61, interval 12–13 cm, Late Pleistocene.

**Diagnosis.** *?Eucytherura* with convex dorsal margin, low longitudinal ridges and intercostal reticulation in posterior half. Reticulation grades to dense punctation distally. Weakly alate posteroventrally. Median hinge element sinuous.

**Description.** Very small, subovate in lateral and dorsal view, shell moderately well calcified. Anterior margin convex; posterior margin short and convex. Dorsal margin convex, weakly undulating; ventral margin gently biconvex. Weakly inflated, slightly longitudinally swollen posteroventrally. Diffuse longitudinal ridges through posterior half with intercostal reticulation bounding well rounded fossae and secondarily reticulate, grading to fine, dense punctation distally. Adductor muscle scars large, four in a subvertical row anteroventral of valve centre, frontal scar subreniform, just ahead of dorso-median adductor scar; normal pores, simple and well distributed, internally emergent at base of large pits. Antimerodont hinge: finely crenulate, flexured median element; in RV, terminal elements finely denticulate, narrow and elongate, tapering under ends of median element. Inner lamella moderately broad anteriorly, with small crescentic vestibulum, narrow ventrally with narrow vestibulum. Few radial pore canals, 4–5 true anteriorly, 3 posteroventrally.

**Comparisons.** The species can be distinguished from *?E. polydictyota* n.sp. by its more curved dorsal margin, less distinct ridges and reticulation, and lack of an alar ridge. It is placed only tentatively within *Eucytherura* due to its lack of normal pore clusters.

**Distribution.** Found only in the Late Quaternary of the type locality.

*Eucytherura calabra* (Colalongo & Pasini, 1980)

Fig. 3 A–D

*Typhloeucytherura calabra* Colalongo & Pasini, 1980: 122; pl. 20, figs 1–8; pl. 21, figs 1–2.

*?Eucytherura hirsuta* Ciampo, 1980: 16; pl. 3, figs 2,4.

*Eucytherura calabra*.—Whatley & Coles, 1987: pl. 3, figs 14–16.—Whatley & Ayress, 1988: pl. 1, figs 9a,b.—Ayress, 1988\*: 607; pl. 21, figs 8–11.

*Eucytherura* sp. 1 Ruan & Hao, 1988: 291; pl. 49, fig. 18. "*Eucytherura palatuberculata*" Davies, 1981\*: 145; pl. 3, figs 15,16.—Porter, 1984\*: 152; pl. 9, figs 4,5.

"*Eucytherura reticulospinosa*" Smith, 1983\*: 87; pl. 8, fig. 6.—Downing, 1985\*, pl. 29, figs 13–15.—Millson, 1987\*: 282; pl. 15, figs 9–14.

**Remarks.** Colalongo & Pasini (1980) assigned this species to a new genus *Typhloeucytherura* based on its lack of an eyespot and considerable difference from the only blind cytherurine genus, *Typhlocythere*, then available to them. Maddocks & Steineck (1987) further identified certain unique carapace features of *T. calabra* that might serve to distinguish the genus from *Eucytherura*. In our evaluation of species during this study we are unable to assign any of them confidently to *Typhloeucytherura* as presently diagnosed, formally or otherwise. We feel that the features identified as unique for *Typhloeucytherura* are variable in nature and serve to distinguish taxa only at the species level.

**Distribution.** The species is widespread in the deep-sea. In the Indo-Pacific material considered in this study the species has been recorded both at bathyal and abyssal site depths in the south-west Pacific: coretops TL 8730, TS 8648; Late Quaternary cores OSI 12–87/12GC9, 13GC10, 1–86/6GC3, 6–85/25GC18, Sonne 36–61; Pleistocene of DSDP Sites 207A, 209, 289; Middle Miocene to Pliocene of DSDP Sites 207A and 209; Late Oligocene to Late Pleistocene of DSDP Site 593; Late Eocene to Early Pleistocene of DSDP Site 592; Early Eocene and Late Oligocene of DSDP Site 277; Early to Middle Eocene of DSDP Site 207A; in the eastern Indian Ocean: Pleistocene of DSDP Sites 258 and 259. The species also occurs in the Mediterranean, Atlantic and Okinawa Trough.

n.sp., K, external lateral view of adult left valve (OS 14066), Middle Eocene, L, internal view of adult left valve (OS 14067), Middle Eocene, M, external lateral view of adult right valve (holotype, OS 14065) Middle Eocene; N–O, *Eucytherura* sp. 3, N, internal view of adult right valve (MA/IP/400) from DSDP Site 209, core 1, section 1, Late Pleistocene; O, external lateral view of same specimen.

*Eucytherura downingae* (Coles & Whatley, 1989)

Fig. 4 E

*Eucytherura* sp. 3 Whatley & Coles, 1987: pl. 3, fig. 19.  
 “? Gen. et sp. 3” Ruan & Hao, 1988: 389; pl. 45, fig. 22.  
 “Gen. 1 et sp.” Ruan, 1989: 131; pl. 24, figs 15, 16.  
*Parahemingwayella downingae* Coles & Whatley, 1989: 91;  
 pl. 2, figs 14–16.  
 “*Eucytherura batalaria*” Ayress, 1988\* (in part), p. 582, pl.  
 20, fig. 5.

**Remarks.** This species is closely similar to the Pacific *Eucytherura batalaria* n.sp. but differs from that species in having a posterodorsal tubercle and less rugose ornament. The specimen illustrated by Whatley & Coles (1987) displays a rather weakly developed posteroventral tubercle and is here considered to be a variant of this species. Ruan & Hao (1988) illustrate a very similar form found in Quaternary sediments of the Okinawa Trough which, although it has an unusually high anterior hinge ear for this species, is probably conspecific.

**Distribution.** Found in this study in the Late Pleistocene of Tasman Sea cores Sonne 36–61, 1–86/6GC3 and Coral Sea DSDP core 209.

*Eucytherura elegantula* n.sp.

Fig. 4 K–M

“*Eucytherura elegantula*” Millson, 1987\*: 283; pl. 15, figs 15–18.

**Etymology.** Latin, very fine. Referring to the elegant ornamentation of the carapace.

**Type material and dimensions.** Holotype, OS 14065, adult right valve, length 0.34 mm, height 0.19 mm. Paratypes: OS 14066, adult left valve, length 0.35 mm, height 0.19 mm, OS 14067, adult left valve, length 0.35 mm, height 0.20 mm. All specimens are from the type locality.

**Type locality and horizon.** Lord Howe Rise, present day water depth 1389 m, DSDP Site 207A, core 11, section 4, interval 85–90 cm, Middle Eocene, Zone NP 16.

**Diagnosis.** A non tuberculate species of *Eucytherura* with weak posteroventral inflation. Uniformly reticulate with raised mural conjunctions and fine inwardly directed spines. Marginal and posteroventral regions bear long spines which may have clavate or secondarily spinose terminations. Anterior marginal rim has laterally projecting as well as forward projecting spines.

**Description.** Small sized, subtriangular in lateral view, weakly inflated and thinly calcified. Anterior margin

convex with thin rim. Ventral margin sinuous tapering to short posterior margin dorsally. Dorsal margin straight. Posteroventral tubercle weakly developed, strongly spinose, spines usually clavate. Whole surface covered by a regular reticulum: muri with raised conjunctions and edged with fine inwardly directed spines. Long spines, with secondarily spinose terminations over marginal regions. Internal features were preserved as for genus. Radial pore canals and muscle scars not preserved.

**Comparisons.** This species is easily distinguished from most other species of *Eucytherura* by its distinctive spinose ornament and lack of tuberculation. It is similar to *Eucytherura ginginensis* (Boomer & Whittaker, 1994) from the Late Cretaceous Gingin Chalk of Western Australia. However, differences between these species can be seen in the nature and distribution of the external spines. For example, *E. ginginensis* has only marginal spines well developed on the anterior marginal rim, whereas *E. elegantula* has both laterally and anteriorly directed spines well developed.

**Distribution.** Known only from the Early to Middle Eocene of DSDP Site 207A.

*Eucytherura indianensis* n.sp.

Fig. 3 E–H

“*Eucytherura indianensis*” Ayress, 1988\*: 611; pl. 21, figs 12–17.

**Etymology.** From its occurrence in the Indian Ocean.

**Type material and dimensions.** Holotype, OS 14068, adult left valve, length 0.35 mm, height 0.23 mm. Paratypes: OS 14069, adult right valve, length 0.37 mm, height 0.23 mm, Site 254, core 1, section 2, interval 20–26 cm, Pleistocene; OS 14070, adult right valve, length 0.37, height 0.23 mm, Site 254, core 1, section 3, interval 50–56 cm, Pleistocene.

**Type locality and horizon.** East Indian Ocean, southern limit of Ninetyeast Ridge, present day water depth 1253 m, DSDP Site 254, core 1, section 2, interval 20–26 cm, Pleistocene.

**Diagnosis.** A species of *Eucytherura* with a very bluntly convex anterior margin and very short sub-dorsal caudal process. Coarsely reticulate with polygonal fossae; muri bear short conjunctive and disjunctive lateral spines and inwardly directed spines. Anterior half of ventral surface microreticulate. Low mid-anterior ridge extends onto posteroventral tumidity.

**Description.** Small, sub-quadrate in lateral view. Anterior margin bluntly convex; posterior margin with short

caudal process just above mid-height. Dorsal margin straight to slightly undulating with distinct anterior cardinal angle. Ventral margin tapers upwards posteriorly, interrupted by posteroventral tumidity which overhangs and overreaches ventral margin. Lateral surface coarsely reticulate: fossae deep and polygonal, muri bear short, blunt conjunctive and disjunctive spines and fine inwardly directed spines. Low ridge extends longitudinally through mid-anterior and obliquely across ventral tumidity, interrupted medianly by thickened mural strut associated with adductor muscle scars. A second low arcuate ventro-lateral ridge borders a sub-ovate microreticulate region in anterior half of ventral surface. Internal surface with clusters of 6–7 perforations. Other internal features as for genus.

**Comparisons.** The species is similar to *E. calabra* (Colalongo & Pasini), but differs from that species in having much shorter spines and a microreticulate anteroventral surface. In this latter respect it is similar to *E. tumida* n.sp., however, that species lacks spines or ridges and the cells of the microreticulation are more ordered.

**Distribution.** Found only in the Late Pliocene to Pleistocene of DSDP Site 254 on the Ninetyeast Ridge, eastern Indian Ocean.

#### *Eucytherura multituberculata* n.sp.

Fig. 5 A–E

?*Tuberculocythere* sp. Cronin, 1983: pl. VI, fig. A.

"*Eucytherura* sp." Davies, 1981\*: 147.

"*Eucytherura* sp. 2" Porter, 1984\*: 155, pl. 9, fig. 11.–Whatley & Coles, 1987: pl. 3, fig. 18.–Millson, 1987\*: 287; pl. 15, figs 21–23.

"*Eucytherura multituberculata*" Downing, 1985\*: 442; pl. 29, figs 1,2.–Ayress, 1988\*: 594; pl. 20, figs 18–21.

**Etymology.** Latin. Referring to the numerous tubercles which ornament this species.

**Type material and dimensions.** Holotype, OS 14071, adult left valve, length 0.30 mm, height 0.18 mm. Paratypes: OS 14072, adult right valve, length 0.30 mm, height 0.18 mm, Site 209, core 1, section 1, Late Pleistocene; OS 14073, adult left valve, length 0.30 mm, height 0.19 mm, Site 209, core 2, section 2, Early Pleistocene.

**Type locality and level.** Lord Howe Rise, present day water depth 1389 m, DSDP Site 207A, core 1, section 1, interval 45–57 cm. Early Pliocene, Zone NN 14.

**Diagnosis.** *Eucytherura* with valve surface bearing four lateral swellings or nodes as follows: a large, subcentral node of circular section; irregular, spinose posteroventral node; angular anterodorsal node; and an irregular

posterodorsal node. A short, almost vertically aligned ridge present high on the dorsal surface close to mid-length. Remainder of valve surface both primarily and secondarily reticulate.

**Description.** Small, subrectangular in lateral view. Anterior margin bluntly rounded, asymmetrical, extremity below mid-height with six well-spaced denticles, uppermost three strongest forming prominent blunt spines. Posterior margin convex with short caudal process just above mid-height. Dorsal margin straight to slightly convex, punctuated by tuberculate ornament. Ventral margin convex with a shallow oral incurvature just ahead of mid-length. Thick-shelled, not well inflated. Reticulate and tuberculate. Distinct tubercle just anteroventral of centre, circular in section with variable ridged or spinose rounded summit. Well-developed, irregular, longitudinally extended, spinose tubercle partially obscured by strong primary muri which form short conjunctive spines and ridges on the tubercle, at anterodorsal corner and high on the posterodorsal corner. Weak subvertical ridge extends between the ventral tubercles terminating mid-dorsally at a strong dorsal spine. Smooth, narrow ventro-lateral ridge curves from anteroventral corner, subparallel to ventral margin, terminates just ventral to an irregularly spinose posteroventral tubercle. Remainder of valve surface covered with irregular primary reticulation, and an almost equally strong secondary reticulum. Marginal rims narrow and smooth. Ventral surface primarily and coarsely secondarily reticulate; two thin costae occur in anterior field, these diverge toward mid-length subparallel to ventral margin. Numerous conjunctive pore conuli. Internal features as for genus.

**Comparisons.** *Eucytherura multituberculata* is similar in shape and tuberculate nature to *Eucytherura complexa* Brady, 1866, a species widely distributed in shallow water. The reticulation of the latter species differs, however, in having a trefoil fossal pattern. Certain features of *E. multituberculata* are notably variable, particularly the strength of the secondary reticulation and development of the mid-dorsal spine. The latter feature is absent in specimens of Cretaceous to Eocene age of the Tasman Sea and those found on the Ita Mai Tai Guyot (DSDP Site 200).

**Distribution.** This species is known from the Tasman Sea in the Late Palaeocene to Pliocene of DSDP Site 207A, in the Late Cretaceous of DSDP Site 208; from the Coral Sea in the Miocene and Pleistocene of DSDP Site 209; from the Ita Mai Tai Guyot, western Pacific in the Miocene and Pleistocene of DSDP Site 200; Late Pleistocene of Sonne 36–61 and OSI 1–86/6GC3; Recent (coretop) of cores TS 8637 and TS 8655; and from the Pleistocene eastern Indian Ocean DSDP Sites 253 and 254. Occurrences outside the Indo-Pacific region include the Recent North Atlantic records of Cronin (1983) 1029 m from the Blake Plateau, western mid Atlantic; Davies (1981) from depths between 500–2000 m of the north

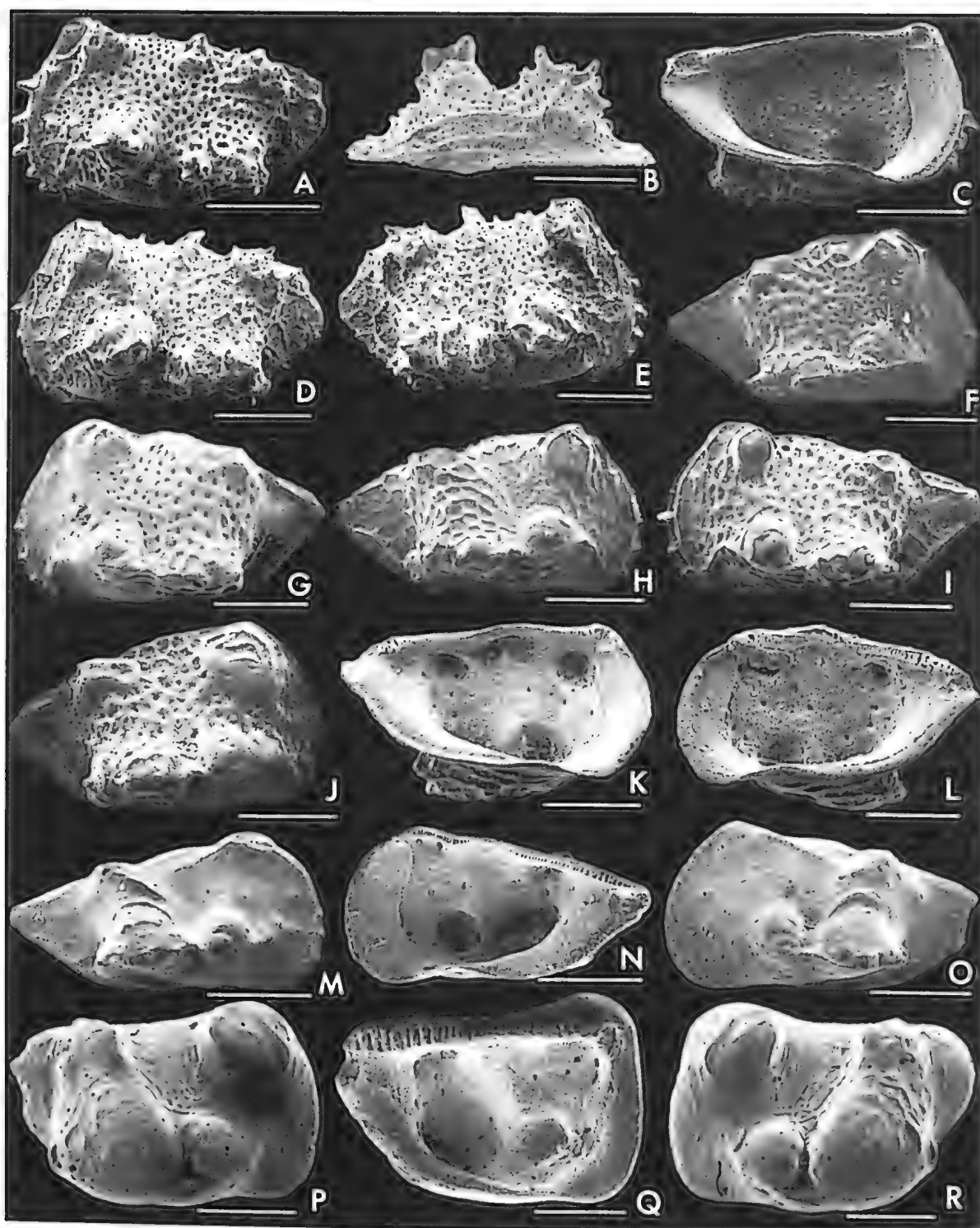


Fig. 5. Scanning electron micrographs. All scale bars are 100  $\mu\text{m}$ . A–E, *Eucytherura multituberculata* n.sp., A, external lateral view of adult left valve (OS 14073), Early Pleistocene, B, ventral view of same specimen, C, internal view of adult left valve (MA/IP/404) from DSDP Site 209, core 2, section 2, Early Pleistocene, D, external lateral view of adult left valve (SD/WPP/329) from DSDP Site 207A, core 3, section 1, Early Pliocene, E, external lateral view of adult right valve (SD/WPP/330) from DSDP Site 207A, core 3, section 5, Early Pliocene; F–L, *Hemiparacytheridea leopardina* (Ruan & Hao, 1988), F, external lateral view of adult right valve (OS 14079), Late Pleistocene, G, external lateral view of adult left valve (OS 14077), Early Pleistocene, H, external lateral view of adult right valve (MA/IP/409) from DSDP Site 209, core 1, section 1, Late Pleistocene, I, external lateral view of adult left valve (SD/WPP/337) from DSDP Site

eastern Atlantic; and Whatley & Coles (1987) from abyssal depths in the central Atlantic in the Late Pliocene.

*Eucytherura pacifica* n.sp.

Fig. 6 F–I

"*Typhlocythere pacifica*" Smith, 1983\*: 92, pl. 8 fig. 11.–Dainty, 1984\*: 219.–Downing, 1985\*: 454; pl. 29, figs 17,18.–Ayress, 1988\*: 634; pl. 22, figs 16–18.

**Etymology.** From its occurrence in the south-west Pacific.

**Type material and dimensions.** Holotype, OS 14086, adult left valve, length 0.34 mm, height 0.22 mm. Paratypes: OS 14087, adult right valve, length 0.31 mm, height 0.19 mm, Site 209, core 2, section 6, interval 75–80 cm, Early Pleistocene, Zone NN 19; OS 14088, adult right valve, length 0.28 mm, height 0.20 mm, Site 208, core 5, section 6, interval 7–18 cm, Late Pleistocene, Zone NN 21.

**Type locality and level.** Lord Howe Rise, present day water depth 1428 m, DSDP Site 209, core 2, section 6, interval 75–80 cm, Early Pleistocene, Zone NN 19.

**Diagnosis.** *Eucytherura* rounded, subrhomboidal lateral outline, tumid posteroventrally. Coarsely reticulate, fossae partially celate. Anterior and posterior marginal and ventral surface microreticulate.

**Description.** Small, sub-rhomboidal in lateral view. Anterior margin broadly rounded; asymmetrical, extremity below mid-height. Posterior margin convex with very short caudal process sub-dorsally. Dorsal margin slightly sinuous. Ventral margin slightly convex interrupted by posteroventral tumidity. Moderately thick-shelled and tumid posteroventrally, compressed only postero-marginally. Lateral surface coarsely reticulate, fossae mostly polygonal except anteriorly and over posteroventral swelling where fossae are partially celated and well rounded. Anteriorly primary muri aligned sub-parallel to anterior margin. Ventral surface and anterior and posterior marginal regions microreticulate. Surface of inner lamella with clusters of about 6 pores. Other internal features as for genus.

**Comparisons.** This species is most similar to *Eucytherura ruggierii* (Bonaduce, *et al.*, 1975) of the Adriatic Sea, from which it differs in its partially celate fossae and ventral microreticulation.

**Distribution.** Widely distributed in the south-west Pacific region: Late Oligocene to Early Pleistocene of DSDP Site 593; Middle Miocene and Pleistocene of DSDP Site 207A and 209, Early Miocene to Late Pleistocene of DSDP Site 592; Pliocene to Pleistocene of DSDP Site 208; Pleistocene of DSDP Sites 277, 282 and 284; Late Pleistocene of cores Sonne 36–61 and OSI 1–86/6GC3.

*Eucytherura parabatalaria* n.sp.

Fig. 4 F–J

"*Eucytherura* cf. ?*Cytheropteron tetrapteron* (Bonaduce, Giampo & Masoli)" Porter, 1984\*: 153; pl. 9, figs 6,7. "*Eucytherura parabatalaria*" Ayress, 1988\*: 585; pl. 20, figs 6–12.

**Etymology.** Greek, close. Referring to the close similarity of this species to *Eucytherura batalaria* n.sp.

**Type material and dimensions.** Holotype, OS 14083, adult right valve, length 0.33 mm, height 0.19 mm. Paratypes: OS 14084, adult left valve, length 0.36 mm, height 0.19 mm; OS 14085, adult right valve, length 0.34, height 0.17 mm. All specimens from Site 254, core 1, section 3, interval 50–56 cm, Pleistocene.

**Type locality and horizon.** East Indian Ocean, southern limit of Ninetyeast Ridge, present day water depth 1253 m, DSDP Site 254, core 1, section 3, interval 50–56 cm, Pleistocene.

**Diagnosis.** A species of *Eucytherura* with a gently sinuous dorsal margin and two ventral tubercles, the anterior-most subhemispherical with a low longitudinal ridge, the posterior-most elongate and somewhat tumid. L-shaped ridge posterodorsally; Coarsely primarily reticulate, fossae polygonal, and uniformly secondarily reticulate. Whole of ventral surface microreticulate.

**Description.** Small, elongate sub-triangular in lateral view. Strongly sexually dimorphic: male valves more elongate than female valves. Anterior margin convex,

208, core 4, section 4, late Pliocene, **J**, external lateral view of adult right valve (SD/WPP/335) from DSDP Site 207A, core 3, section 5, Early Pliocene, **K**, internal view of adult left valve (SD/WPP/340) from DSDP Site 208, core 4, section 4, Late Pliocene, **L**, internal view of adult right valve (SD/WPP/339) from DSDP Site 206, core 16, section 3, Late Pliocene; **M–O**, *Hemiparacytheridea vanharteni* n.sp., **M**, external lateral view of adult right valve (holotype, OS 14582) Early Pleistocene, **N**, internal view of same specimen, **O**, external lateral view of adult left valve (OS 14583) Pleistocene; **P–R**, *Hemiparacytheridea mediopunctata* (Coles & Whatley), **P**, external view of right valve (MA/IP/430) from DSDP Site 254, core 1, section 3, Early Pleistocene, **Q**, internal view of adult left valve (MA/IP/431) from DSDP Site 254, core 2, section 1, Late Pliocene, **R**, external lateral view of adult right valve (MA/IP/429) from DSDP Site 254, core 1, section 2, Pleistocene.



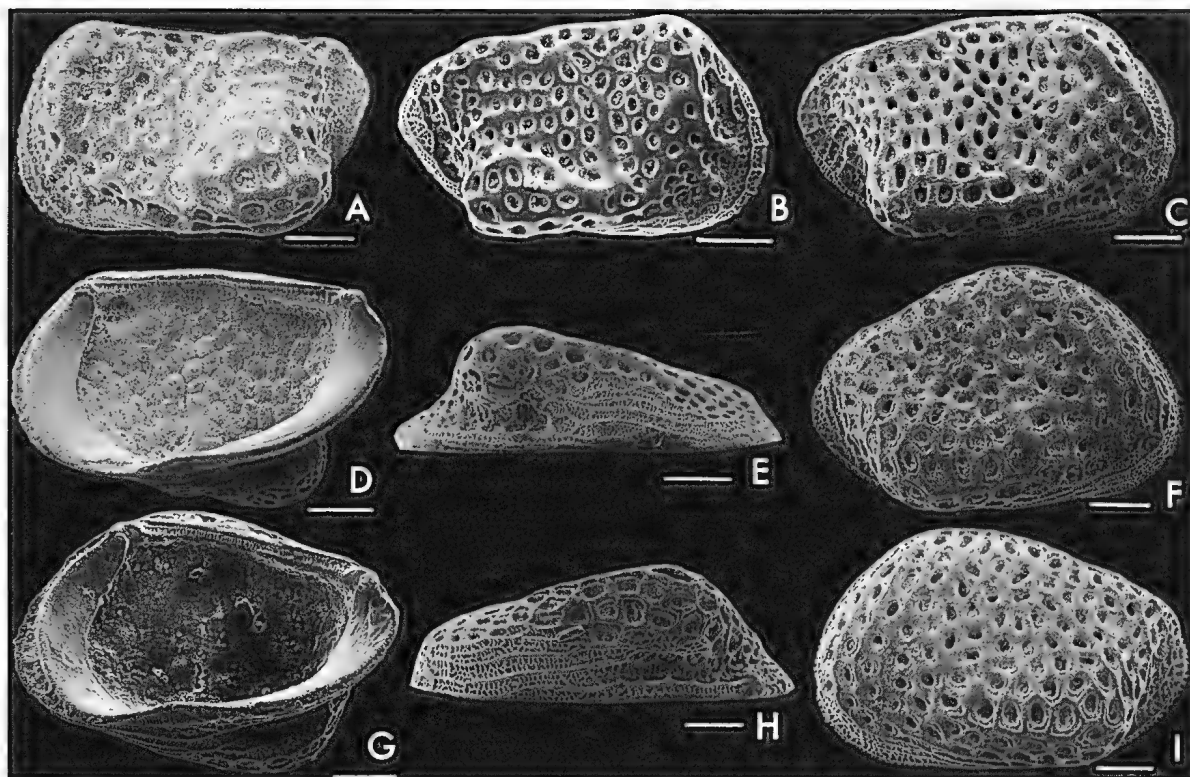


Fig. 6. Scanning electron micrographs. All scale bars are 50  $\mu$ m. A–E, *Eucytherura* sp. 2, A, external lateral view of adult left valve, specimen lost, from DSDP Site 593, core catcher 44, Early Miocene, B, external lateral view of adult right valve (AMF 91148) from eastern Australian continental slope, sample details unknown, C, external lateral view of adult right valve (MA/IP/427) from DSDP Site 209, core 2, section 2, Early Pleistocene, D, internal view of same specimen, E, ventral view of same specimen; F–I, *Eucytherura pacifica* n.sp., F, external lateral view of adult right valve (SD/WPP/348) from DSDP Site 208, core 5, section 6, Late Pliocene, G, internal view of same specimen, H, ventral view of adult left valve (MA/IP/435) from DSDP Site 209, core 2, section 6, Early Pleistocene, I, external lateral view of adult left valve (holotype, OS 14086) Early Pleistocene.

asymmetrical, strongly rimmed, with a strong denticle at mid-height and two shorter downward projecting denticles anteroventrally. Posterior margin short, straight to slightly convex with two denticles, one at each corner. Dorsal margin sinuous, gently convex ahead of mid-third, gently concave behind. Ventral margin biconvex. Moderately thin-shelled and inflated. Tuberculate: well-developed, sub-hemispherical tubercle just anteroventral of centre, bearing a short longitudinal ridge which extends down anterior slope of tubercle. Posteroventral tubercle elongate longitudinally with a low spine midway on posteroventral slope. L-shaped ridge close to margin posterodorsally formed by accentuated mural elements. Coarse primary reticulation over entire lateral surface, fossae polygonal; muri on anterior rim form a continuous ridge, and muri form a smooth border along anterior half of dorsal margin. Uniformly secondary reticulate, primary fossae subdivided into 5 rounded sub-fossae which are sometimes edged by

numerous short ingrowing spines. Ventral surface microreticulate. Ventro-lateral smooth narrow ridge extends from margin anteroventrally across ventral surface. Internal surface of outer lamella with clusters of 4 to 5 normal pores. Other internal features as for genus.

**Comparisons.** This species is most similar to *Eucytherura batalaria* n.sp., *Eucytherura downingae* (Coles & Whatley) and the Mediterranean *Eucytherura tetrapterion* (Bonaduce et al.). It can be distinguished from the former two species by its lack of spinosity and more extensively distributed ventral microreticulation, and from the latter species by its more regular primary reticulation.

**Distribution.** Recorded only from the eastern Indian Ocean in the Pleistocene of DSDP Sites 253, 258 and 259, and in the Late Pliocene to Pleistocene of DSDP Site 254.

*?Eucytherura polydictyota* n.sp.

Fig. 2 H-N

**Etymology.** Greek, many plus net. Referring to the varied reticulation on the valve external surface.

**Type material and dimensions.** Holotype, AMF 91146, adult right valve, length 0.25 mm, height 0.14 mm. Paratype: AMF 91145, adult right valve, length 0.25 mm, height 0.14 mm, from core Z2108/3, level 65 cm, Late Pleistocene; AMF 91147, adult left valve, length 0.24 mm, height 0.13 mm, from the type locality and horizon.

**Type locality and horizon.** Western flank of Lord Howe Rise, present day water depth 1340 m, Sonne Core 36-61, level 41 cm. Late Pleistocene.

**Diagnosis.** An alate species of *?Eucytherura* with strong ventro-lateral ridge, and median ridge which joins dorsal ridge in a posterior loop. Murae thickened over position of adductor muscle scars. Surface reticulate: fossae large centrally grading to dense secondary reticulation distally. Median hinge element slightly flexured. Normal pores well distributed with one conspicuously positioned between the anterior ends of the median adductor scars.

**Description.** Very small, subrectangular to subtriangular in lateral view. Anterior margin convex with apex below mid-height. Posterior margin convex and very narrow with extremity at mid-height. Dorsal margin straight to slightly undulating, with small anterior hinge ear. Ventral margin biconvex about median oral incurvature. Moderately well inflated ventrally forming a blunt alar process which bears a distinct ridge anteriorly. Adductor muscle scar region distinct externally as a low hemispherical swelling just anteroventral of valve centre. A second conspicuous ridge extends across central field tapering at each end, looping backwards posterodorsally. Remainder of lateral surface covered with reticulation. Fossae large centrally and mid dorsally, are secondarily subdivided and elsewhere. Primary murae diminish in strength away from valve mid-length, becoming almost equal with fine secondary murae over distal compressed regions and over ventral surface. Normal pores well distributed with one inserted between the anterior ends of the median adductor scars. Adductor muscle scars large, four in a subvertical row anteroventral of valve centre, frontal scar subreniform, just ahead of dorso-median adductor scar; normal pores, simple and well distributed, internally emergent at base of large pits. Antimerodont hinge: finely crenulate median element; in RV, terminal elements finely denticulate, narrow and elongate, tapering under ends of median element. Inner lamella moderately broad anteriorly, with small crescentic vestibulum, narrow ventrally with narrow vestibulum. Few radial pore canals, 4-5 true anteriorly, 3 posteroventrally.

**Comparisons.** This species can be confused with *?Eucytherura boomeri* n.sp. but the alate ventrum, strong median ridge and subcentral tubercle, with its central normal pore, readily serve to distinguish this species. Its normal pores are not clustered, for this reason it is only tentatively placed within *Eucytherura*.

**Distribution.** Western flank of Lord Howe Rise, present day water depths 1340 m and 1448 m of cores Sonne 36-61, level 41 cm and Z2108/3, level 65 cm respectively; both occurrences are of Late Pleistocene age.

*Eucytherura pseudoantipodum*  
Coles & Whatley, 1989

Fig. 3 O-P

*"Eucytherura* sp. 7" Ayress, 1988\*: 621; pl. 22, figs 5,6. *Eucytherura pseudoantipodum* Coles & Whatley, 1989: 93; pl. 3, figs 5-7.

**Remarks.** The two specimens found in this study seem to conform to *E. pseudoantipodum* Coles & Whatley, known from the Middle Eocene to Late Oligocene of the North Atlantic. Some minor differences between the Atlantic and Pacific material can be seen, such as the somewhat straighter dorsal margin and fossal spines of the Pacific forms. Such differences could be attributable to geographic variation.

**Distribution.** In this study the species was recorded only in the Pleistocene of DSDP Site 209, Queensland Plateau.

*Eucytherura tumida* n.sp.

Fig. 3 K-N

*"?Typhlocytheré tumida"* Ayress, 1988\*: 638; pl. 22, figs 23-24; pl. 23, figs 1-5.

**Etymology.** Latin. Referring to the tumid ventro-lateral inflation of this species.

**Type material and dimensions.** Holotype, OS 14074, adult right valve, length 0.34 mm, height 0.22 mm. Paratypes: OS 14075, adult left valve, length 0.34 mm, height 0.20 mm, Site 254, core 1, section 2, interval 20-26 cm, Pleistocene; OS 14076, adult left valve, length 0.33, height 0.20 mm, Site 254, core 1, section 3, interval 50-56 cm, Pleistocene.

**Type locality and horizon.** East Indian Ocean, southern limit of Ninetyeast Ridge, present day water depth 1253 m, DSDP Site 254, core 1, section 2, interval 20-26 cm, Pleistocene.



**Diagnosis.** A sub-rectangular to sub-ovate, ventro-laterally tumid species of *Eucytherura*. Strongly reticulate, fossae somewhat vertically aligned in posterior half, arranged in rows parallel to anterior margin in anterior half. Ventral surface conspicuously ornamented with microreticulation which extends to anterior and posterior marginal regions; ventral microreticulate field expanded in anterior half and regularly arranged between five primary mural rows.

**Description.** Small sized, sub-rectangular to sub-ovate in lateral view. Anterior margin bluntly convex; posterior margin with extremely short caudal process just below dorsal margin. Dorsal margin straight to slightly convex; ventral margin gently convex, oral incurvature indistinct. Moderately thick shelled and well inflated; tumid posteroventral swelling overhangs ventral margin. Coarsely reticulate: fossae deep and ovate, subvertically aligned in posterior half, concentrically aligned in anterior half; edges of muri rarely bear incipient ingrowing spines. Sinuous ventro-lateral ridge borders primary reticulation and ventral microreticulation, the latter extends to anterior and posterior marginal regions. Anterior half of ventral surface with a conspicuous field of microreticulation infilling five rows of horizontally aligned thin primary muri. Normal pore canals numerous and well spaced. Internal pore clusters consist of clusters of 2–3 pores. Other internal features as for genus.

**Comparisons.** This species differs from *E. indianensis* n.sp. primarily in its more ordered reticulum, less angular outline and lacks the longitudinal anterior ridge.

**Distribution.** Late Pliocene to Pleistocene of DSDP Site 254 on the Ninetyeast Ridge, eastern Indian Ocean.

### *Eucytherura* sp. 1

Fig. 3 I–J

"*Eucytherura* sp." Ayress, 1988\*: 616; pl. 21, figs 22,23.

**Dimensions.** Adult right valve, MA/IP/421, length 0.36 mm, height 0.20 mm.

**Diagnosis.** *Eucytherura* with sub-rectangular lateral outline and strongly caudate. Reticulation of irregular polygonal fossae with thin delicate inwardly directed spines and lateral spines, both conjunctive and disjunctive, strongest on posteroventral swelling. Solum perforated by fine pores reflected internally by a regular pattern of 9–10 pore clusters. Narrow, straight accommodation groove above hinge.

**Distribution.** Only a single specimen was recorded from the Early Pleistocene of DSDP Site 209, Queensland Plateau.

### *Eucytherura* sp. 2

Fig. 6 A–E

"*Eucytherura* sp. 9" Ayress, 1988\*: 626; pl. 22, figs 10–12.

**Dimensions.** Adult right valve, MA/IP/427, length 0.29 mm, height 0.18 mm.

**Diagnosis.** A subrectangular species of *Eucytherura* with a somewhat bulbous posteroventral swelling which overreaches ventral margin. Short ridge anterodorsally and posterodorsally. Lateral surface coarsely reticulate, fossae well rounded, ventral surface microreticulate.

**Comparisons.** Although very similar to *E. pacifica* it can be distinguished from that species by its more rectangular lateral outline, its more irregular inflation and dorsal ridges. It is left in open nomenclature due to paucity of material.

**Distribution.** Late Pleistocene of eastern Australian continental shelf, Early Pleistocene of DSDP Site 209, Queensland Plateau, and Early Miocene of DSDP Site 593, Lord Howe Rise.

### *Eucytherura* sp. 3

Fig. 4 N–O

"*Eucytherura* sp. 2" Ayress, 1988\*: 591; pl. 20, figs 16,17.

**Dimensions.** Juvenile ?A–1 right valve, MA/IP/400, length 0.32 mm, height 0.17 mm.

**Diagnosis.** *Eucytherura* with a deep-concavity in dorsal margin corresponding to a sinuous median hinge element at anterior third of valve length. Primarily and secondarily reticulate. Two ventro-lateral tubercles high on lateral surface.

**Comparisons.** Although this species is similar in many respects to *Eucytherura batalaria* n.sp. it can easily be identified by its dorsal concavity. This feature is present in *Eucytherura tetrapterion* (Bonaduce et al.) but that species clearly differs in its distinctive surface mural pattern.

**Distribution.** In the study region this species has been recorded only from the Late Pleistocene of DSDP Site 209, Queensland Plateau. It is also known from 2580 m in the central North Atlantic (pers. comm. Van Harten, 1985).

*Hemiparacytheridea* Herrig, 1963

**Type species.** *Hemiparacytheridea occulta* Herrig, 1963

**Diagnosis.** A genus of the subfamily Cytherurinae with a small carapace of subrectangular or quadrate lateral outline commonly with long caudal process above mid-height. Posteroventral and subcentral tubercle present often forming a bitubercular alar structure. Eye tubercle present or absent. Normal pore canals large and regularly distributed. Muscle scars consist of four subovate adductor

scars in a vertical row and a subreniform frontal scar ahead of the row. Hinge, in right valve, consists of a small circular anterior terminal tooth, posterior tooth very much reduced or absent, and a locellate median groove expanded posteriorly.

**Comparisons.** This genus lacks the solum pore clusters and distinct posterior terminal hinge element of *Eucytherura*. *Tuberculocythere* Colalongo & Pasini, 1980 also lacks these features and is considered to be a strongly tuberculate form of *Hemiparacytheridea*.

**Key to Deep-sea Species of *Hemiparacytheridea***

1. Ventral bitubercular alae with curved ventro-lateral ridge;  
extensive reticulate to punctate ornament ..... *leopardina*
- Ventro-lateral ridge absent; ornament only weakly developed ..... 2
2. Dorsal tubercles weakly developed; lateral outline elongate ..... *vanharteni*
- Tubercles well developed and bulbous; lateral outline  
subquadrate ..... *mediopunctata*

*Hemiparacytheridea leopardina*  
(Ruan & Hao, 1988)

Fig. 5 F–L

- "*Eucytherura* sp. 1" Whatley & Coles, 1987: pl. 3, fig. 17.  
 "*Eucytherura* sp. 5" Millson, 1987\*: 291; pl. 16, figs 4,5.  
*Bythoceratina leopardina* Ruan & Hao, 1988: 257, pl. 41, figs 20–23.  
 ?*Typhlocythere tetradosa*.—Ruan, 1989: 123, pl. 22 fig. 24.  
 "*Eucytherura variabile*" Downing, 1985\*: 444; pl. 29, figs 3–9.—Smith, 1983\*: 88, pl. 8 fig. 5.—Ayress, 1988\*: 598, pl. 20 figs 22–24.

**Dimensions.** OS 14077, female left valve, length 0.35 mm, height 0.20 mm; OS 14078, female left valve, length 0.33 mm, height 0.20 mm, both from Site 209, core 2, section 6, interval 75–80 cm, Early Pleistocene, Zone NN 19. OS 14079, female right valve, length 0.33 mm, height 0.20 mm, Site 209, core 1, section 1, interval 75–80 cm, Late Pleistocene, Zone NN 21.

**Emended diagnosis.** *Hemiparacytheridea* with a moderately large posteroventral alar structure, forward from which extends a laterally directed ridge that turns sharply downward just anterior of a hemispherical subcentral tubercle. Ribbed pyramidal tubercle anterodorsally, irregular subtriangular tubercle posterodorsally. Sinuous ridge extends subvertically anterodorsally. Reticulation fossae circular medially, polygonal elsewhere. Caudal process somewhat downturned.

**Comparisons.** Our material of this species displays considerable variation in the strength of the reticulation muri. The ventral bitubercular alar structure and associated downward curving anteroventral ridge, together with the pyramidal anterodorsal tubercle, seem to be consistent diagnostic features of this species and we have no doubt that our material belongs to *H. leopardina*. It is clearly closely related to *Hemiparacytheridea hemingwayi* Neale, 1975 described from the Late Cretaceous Gingin Chalk of Western Australia. The latter species differs only in having a straight dorsal margin. The large anterodorsal tubercle of *H. leopardina* lacks an ocular sinus internally. Neale describes the same tubercle of *H. hemingwayi* as an "eye tubercle" but no internal description is given in support of this interpretation. If indeed ocular structures (glassy lens or internal sinus) are present then these features also could serve to distinguish the two species. A similar species, as yet undescribed, has been recorded in the Middle Eocene to Middle Miocene of ODP Site 214, eastern Indian Ocean (Boomer, pers. comm. 1993) which differs in having a more elongate upturned caudal process.

**Distribution.** Ruan & Hao (1988) first described this species from 1405 m and 1540 m in the Okinawa Trough, East China Sea. Ruan (1988) recorded this species in a Quaternary core taken at 2004 m in the South China Sea. In our material the species is recorded at both bathyal and abyssal depths in the south-west Pacific from the Recent (coretop) of OSI cores 1–86/

19GC11, 12-87/13GC10, TL 8731, 8771, 8730, 8695, TS 8646, 8636; Pleistocene of DSDP Sites 203, 208, 209, 588, Sonne 36-61, AGSO 71GC044, OSI 12-87/12GC9, 1-86/6GC3, Z2108; Pliocene of DSDP Sites 206, 207A, 208 and 289; Late Miocene to Late Pliocene of DSDP Site 592; Middle Miocene of DSDP Sites 62 and 209; Late Oligocene to Early Pliocene of DSDP Site 593; Middle Eocene of DSDP Site 207A; and in the eastern Indian Ocean from the Pleistocene of DSDP Sites 253, 254 and 258. Whatley & Coles (1987) recorded this species in the Late Miocene of DSDP Site 608, North Atlantic.

*Hemiparacytheridea vanharteni* n.sp.

Fig. 5 M-O

"*Eucytherura* sp. 1" Ayress, 1988\*: 589; pl. 20, figs 13-15.  
 "*Eucytherura* sp. 4" Coles, 1989\*, pl. 18, fig. 5.

**Etymology.** For Professor Dick van Harten in recognition of his work on deep-sea Ostracoda.

**Type material and dimensions.** Holotype, OS 14582, adult right valve, length 0.30 mm, height 0.17 mm. Paratype, OS 14583, adult left valve, length 0.30 mm, height 0.16 mm, Site 253, core 1, section 4, interval 13-19 cm, Pleistocene.

**Type locality and level.** Lord Howe Rise, present day water depth 1428 m, DSDP Site 209, core 2, section 6, interval 75-80 cm, Early Pleistocene, Zone NN 19.

**Diagnosis.** *Hemiparacytheridea* with long caudal process, mid-ventral, bitubercular alar process and low pyramidal posterodorsal tubercle. Arcuate ridge behind centre, essentially smooth elsewhere. Normal pores are large with stellate external openings.

**Description.** Small, elongate sub-triangular in lateral view. Anterior margin bluntly convex, asymmetrical, extremity below mid-height and weakly rimmed. Posterior margin acuminate produced into a long caudal process dorsally. Dorsal margin straight, interrupted by low, subtriangular tubercle just behind mid-length; weak hinge ear anteriorly in right valve. Ventral margin weakly biconvex. Thin-shelled; well inflated posteroventrally, rather compressed elsewhere. Large posteroventral longitudinally extended swelling with weak terminal spine, joined to subcentral hemispherical tubercle by low sub-horizontal ridge, together forming a bitubercular alar process mid-ventrally. Low arcuate ridge behind centre and a second ridge extends close to margin anterodorsally, remainder of lateral surface smooth. Normal pores well scattered, external openings large and stellate. Internal features as for genus.

**Comparisons.** This is a distinctive species by virtue of its weak inflation and smooth external surface. It is somewhat similar to *Hemiparacytheridea leopardina* (Ruan & Hao, 1988) but is more elongate and lacks the dorsal tubercle and reticulation of that species.

**Distribution.** Widely distributed but usually rare: Early Pleistocene of DSDP Site 209, Queensland Plateau; Pleistocene of DSDP Site 253, Ninetyeast Ridge; Recent (coretop) of OSI core 12-87/13GC10; Recent and Lower Oligocene of central North Atlantic (Van Harten pers. comm. 1985 and Coles, 1989 respectively). The species has also been found recently at DSDP Guyot Site 171, central Pacific Ocean (Boomer, pers. comm. 1993).

*Hemiparacytheridea mediopunctata*  
 (Coles & Whatley, 1989)

Fig. 5 P-R

*Eucytherura mediopunctata* Coles & Whatley, 1989: 92; pl. 3, figs 2-4.  
 "*Tuberculocythere horrida*" Ayress, 1988\*: 629; pl. 22, figs 13-15.

**Remarks.** Material illustrated here is from DSDP Site 254 in the eastern Indian Ocean, and represents the only record of this species outside the North Atlantic. The Indian Ocean specimens differ slightly from the Atlantic material in having a more inflated posteroventral tubercle which may be attributable to geographical variation. In several species of *Hemiparacytheridea* the degree of inflation of the lateral tubercles can be seen to be rather variable and end members with very swollen tubercles have been placed in *Tuberculocythere* Colalongo & Pasini, 1980. The tubercular inflation is not, therefore, considered to represent a natural generic character, and for this reason *Tuberculocythere* is not used here.

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**Table 1.** Cores from which the genera discussed in the text were recovered together with their stratigraphical and geographical provenience.

Core/grab Site	PDWD(m)	Latitude	Longitude	Age range sampled
<b>South-west Pacific</b>				
DSDP 56	2508	8°22.4'N	143°33.6'E	Middle Miocene
DSDP 62	2591	10°52.2'N	141°56.3'E	Middle Miocene
DSDP 200	1469	12°50.2'N	156°47.0'E	Miocene and Pleistocene
DSDP 203	2720	22°09.22'S	177°32.7'E	Pleistocene
DSDP 206	3196	32°00.75'S	165°27.15'E	Pliocene
DSDP 207A	1389	36°57.75'S	165°26.06'E	M. Palaeocene-L. Pleist.
DSDP 208	1545	26°06.61'S	161°13.27'E	L. Cret.-L. Olig., Plio.-Pleist.
DSDP 209	1428	15°56.19'S	152°11.27'E	M. Eoc.-L. Olig., L. Pleist.
DSDP 277	1214	52°13.43'S	166°11.48'E	M. Palaeocene-L. Olig.
DSDP 289	2206	00°29.92'S	158°30.69'E	Pliocene
DSDP 588	1533	26°06.70'S	161°13.60'E	L. Pleistocene
DSDP 592	1088	36°28.40'S	165°26.53'E	L. Eoc.-L. Pleist.
DSDP 593	1068	40°30.47'S	167°40.47'E	L. Eoc.-L. Pleist.
AGSO 71GC044	1321	29°31.464'S	153°53.976'E	L. Pleistocene
Sonne 36-61	1340	30°33.017'S	161°26.294'E	L. Pleistocene
Z2108	1448	33°22.59'S	161°36.75'E	L. Pleistocene
OSI 6-85/25GC18	2970	48°17.7'S	178°14.8'E	L. Pleistocene
OSI 1-86/6GC3	1540	32°58.8'S	159°59.9'E	L. Pleistocene
OSI 1-86/19GC11	2067	29°57.6'S	159°50.5'E	Recent
OSI 12-87/12GC9	3281	27°23.2'S	165°20.3'E	L. Pleistocene
OSI 12-87/13GC10	1416	29°15.5'S	161°15.3'E	Recent
RC12-210 TL 8771	1529	24.14°S	177.36°E	Recent
RC9-128 TL 8731	1234	36.13°S	166.07°E	Recent
RC9-127 TL 8730	1533	34.01°S	167.54°E	Recent
V24-161 TL 8695	1670	18.12°S	151.27°E	Recent
OPR-476 TS 8655	3040	33.30°S	165.02°E	Recent
NOVA-A48 TS 8646	2220	28.12°S	158.13°E	Recent
ANT 226 TS 8636	2472	18.35°S	176.45°E	Recent
ANT 231 TS 8637	2238	17.09°S	175.54°E	Recent
NOVA-A53 TS 8648	1607	28.08°S	161.31°E	Recent
<b>Indian Ocean</b>				
DSDP 253	1962	24°52.65'S	87°21.97'E	Pleistocene
DSDP 254	1253	30°58.15'S	87°53.72'E	Pleistocene
DSDP 258	2793	33°47.69'S	112°28.42'E	Pleistocene
DSDP 259	4706	29°37.05'S	112°41.78'E	Pleistocene









## ***Zinza*, a New Genus of Rhinotorine Flies from Northern Queensland, Australia (Diptera: Heleomyzidae)**

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**ABSTRACT.** *Zinza grandis* n.gen., n.sp. (Diptera: Heleomyzidae) is described from the Atherton Tableland in northern Queensland. *Zinza* is classified in the tribe Rhinotorini and is related to *Cairnsimyia* Malloch and *Zentula* D. McAlpine. A comparison of these three genera is provided. The egg of *Z. grandis* is also described.

SINCLAIR, BRADLEY J. & DAVID K. MCALPINE, 1995. *Zinza*, a new genus of rhinotorine flies from northern Queensland, Australia (Diptera: Heleomyzidae). Records of the Australian Museum 47(3): 225–230.

The Heleomyzidae (Diptera) are commonly found in temperate forests in most regions, but in the tropics the family inhabits mainly cooler mountainous areas. The tribe Rhinotorini is exceptional in that it is represented in tropical lowlands, both in the Americas and in Australasia, though it extends into temperate areas (e.g., southern Chile, Tasmania). Adult rhinotorines have been found at exudations on tree trunks in Australia, Papua New Guinea, and South America. The only recorded rhinotorine larva lives in cerambycid tunnels in trees (D. McAlpine, 1968). In this paper, the first new Australian rhinotorine genus discovered since the generic revision of D. McAlpine (1985) is described.

Terms used for adult structures primarily follow those of J. McAlpine (1981), except male terminalia where the terms of Cumming *et al.* (1995) are used. To facilitate observation, the terminalia were macerated in hot 85% lactic acid and immersed in glycerin. Specimens cited in this paper are housed in the Australian Museum,

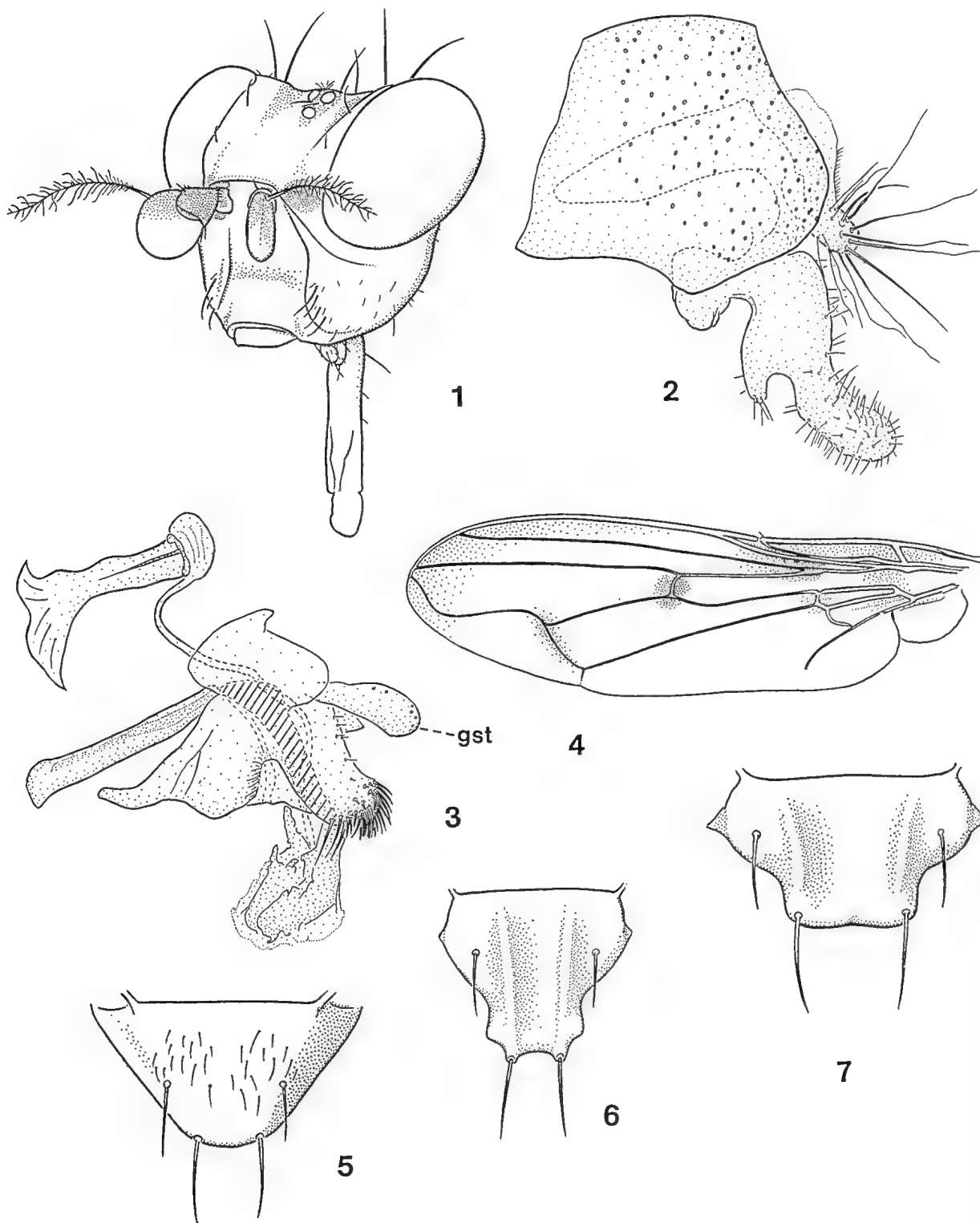
Sydney (AMS) and CSIRO, Division of Entomology, Canberra (ANIC).

### ***Zinza* n.gen.**

**Type species.** *Zinza grandis* n.sp.

**Description.** Large flies, with most of the general characters of the Rhinotorini (D. McAlpine, 1985).

**Head** (Fig. 1) moderately excavated on vertex, ocelli thus not visible in profile; posterior ocelli much closer to each other than to anterior ocellus; ocellar bristles closely approximated, inserted posteriorly to anterior ocellus; vibrissa and 2–3 closely placed peristomial bristles distinct but small; central cheek bristle absent; hypofacial short and narrow. Arista long-plumose beyond basal fifth. Palpus short and compressed.



Figs 1–7. 1, *Zinza grandis* head. 2, *Z. grandis* epandrium, surstylus, cercus. 3, *Z. grandis* hypandrium, phallus, ejaculatory apodeme. 4, *Z. grandis* wing. 5, *Cairnsimyia sydneyensis* D. McAlpine scutellum. 6, *Neorhinotora aristalis* (Fischer) scutellum. 7, *Z. grandis* scutellum. Abbreviation: gst, gonostylus.

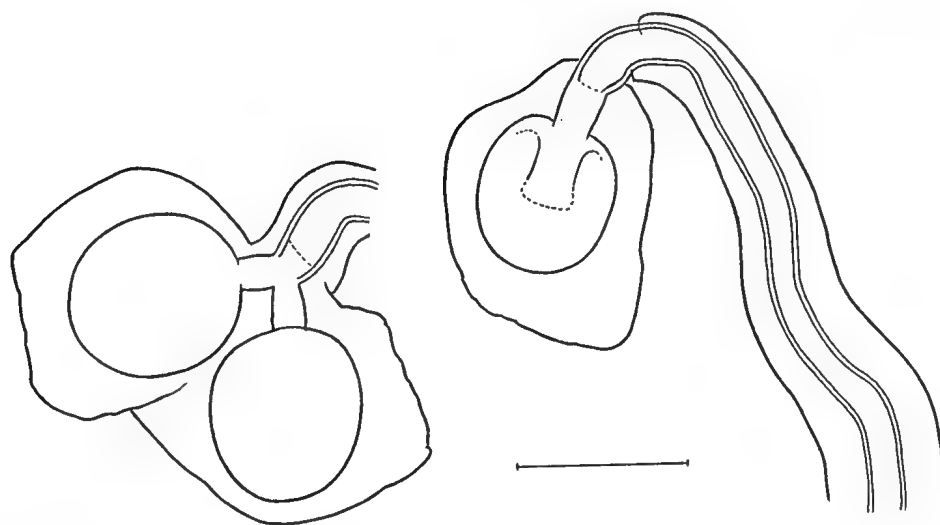


Fig. 8. Spermathecae of *Zinza grandis*. Scale = 0.1 mm.

**Thorax:** scutellum with shallow median channel, without setulae (Fig. 7); proepisternum with fine setulae above, without even vestige of proepisternal bristle below; anepisternum with long scattered setulae, anepisternal bristle lacking; metasternum strongly setulose. Fore coxa enlarged and inflated; fore femur stout, apparently raptorial, less so in female; fore and mid tibiae with distinct, short, preapical dorsal bristle. Wing with few markings, mainly on crossveins (Fig. 4); costa with 1 or 2 anterior spines before subcostal break and often 1 or 2 beyond; postcostal and alular margins with modified fringe; distal separation of Sc and  $R_1$  greater than length of humeral crossvein; distal section of  $M_1$  sigmoid, strongly convergent with  $R_{4+5}$  apically; dm-cu oblique.

**Male postabdomen:** resembling that of *Cairnsimyia* Malloch (details in description of *Z. grandis*).

**Female postabdomen:** tergites and sternites largely unmodified; 3 spermathecae present.

**Remarks.** Adults of the type species of this genus run to couplets 13 and 14 in the key to Australian heleomyzid genera of D. McAlpine (1985), where the choices are *Heleomicra* D. McAlpine, *Zentula* D. McAlpine and *Cairnsimyia*. The plumose arista; setulose metasternum, and strongly apically convergent veins  $R_{4+5}$  and  $M_1$  separate *Zinza* from these genera and all other taxa of Rhinotorini known to us. For a comparison with *Cairnsimyia* and *Zentula*, see Table 1.

**Etymology.** The generic name is a contraction of the Latin *zinzala*, a kind of gnat. Its gender is feminine.

### *Zinza grandis* n.sp.

Figs 1–4, 7, 8

**Material examined.** HOLOTYPE male. North Queensland: 4 km up Mount Edith Road, near Tinaroo Dam, 800 m, 17°05'S 145°38'E, fruit trap, 22–27 Apr. 1994, M.S. Moulds & B.J. Sinclair (AMS). PARATYPES: North Queensland: 1 male, same data as holotype (ANIC); 1 female, Longlands Gap, Atherton district, 1150 m, 17°28'S 145°29'E, Malaise trap, Feb.–Mar. 1995, P. Zborowski (AMS).

**Description.** *Coloration:* head pale yellow; frons shiny gold, with 2 black spots at base of antennae; ocellar triangle dark; vertex with black spot on either side of postverticals; dark spot at base of vibrissa, larger and more distinct in female; scape, pedicel and basal half of first flagellomere brown; ventral surface of first flagellomere mostly pale yellow, less extensively so in female; palpus pale yellow with dark apical setae; proboscis brown. Thorax fulvous; mesoscutum with symmetrical patches of pale yellow, including postpronotal lobe; scutellum brown with median apical yellow marking; pleura with weak brown horizontal stripe on upper margin of proepisternum and anepisternum, brown mark above fore coxa, weak brown stripe across lower margin of anepisternum, upper half of katapisternum, anepimeron, meron, and katatergite. Fore and mid coxae yellow, hind coxa and trochanter brown; fore and mid femora yellow, hind femur brown; apices of femora with black band; tibiae with subbasal and apical black bands; tarsomeres 1–4 yellow, tarsomere 5 dull brown. Wing: membrane yellowish, more intensely so towards base; brown spot

**Table 1.** Comparison of the genera *Zinza*, *Cairnsimyia* and *Zentula*.

<i>Zinza</i>	<i>Cairnsimyia</i>	<i>Zentula</i>
• arista plumose	• arista with micro-pubescence	• arista with micro-pubescence
• posterior ocelli much closer to each other than to anterior ocellus	• posterior ocelli not much approximated	• posterior ocelli not much approximated
• ocellar bristles closely approximated	• ocellar bristles widely separated	• ocellar bristles widely separated
• vertex depressed	• vertex depressed	• vertex not depressed
• lower part of face prominent along most of margin	• lower part of face narrowly prominent, the prominence impressed at sides	• lower part of face prominent along most of margin
• palpus short, compressed	• palpus short, compressed	• palpus elongate, cylindrical
• vibrissa and associated peristomial bristles present	• vibrissa and usually peristomial bristles present	• vibrissa and peristomial bristles absent
• prosternum without setulae	• prosternum with setulae	• prosternum with setulae
• anepisternum sparsely setose	• anepisternum with setulae	• anepisternum without setulae
• proepisternal bristle absent	• proepisternal bristle present, often small	• proepisternal bristle present
• prescutellar acrostichal bristles absent	• prescutellar acrostichal bristles variable	• prescutellar acrostichal bristles present
• scutellar setulae absent	• scutellar setulae present	• scutellar setulae present
• scutellum dorsally channelled	• scutellum dorsally flattened	• scutellum dorsally flattened
• metasternum strongly setulose	• metasternum bare	• metasternum bare
• seriate spots lacking in cells $r_1$ and $r_{2+3}$	• seriate spots present in cells $r_1$ and $r_{2+3}$	• seriate spots present in cells $r_1$ and $r_{2+3}$
• vein $M_1$ strongly curved anteriorly at apex	• $M_1$ not strongly curved anteriorly	• $M_1$ not strongly curved anteriorly
• apical and posterior fringe of wing with modified armature	• apical and posterior fringe of wing normal	• apical and posterior fringe of wing normal

on crossvein r-m and Rs fork, crossing cell  $r_1$ ; small brown spot at apex of cell bm; smoky suffusion present around crossvein dm-cu and wing apex. Haltere pale yellowish. Abdomen bright golden yellow; lateral margins of tergites 1–2 with brown suffusion.

*Head* (Fig. 1): ocellar and postocellar regions forming slight longitudinal convexity within broader frontal excavation; face concave in profile, with lower margin very prominent; postvertical bristle much longer than ocellar; fronto-orbital bristles 2, posterior one short but distinct, anterior one smaller, sometimes little

differentiated from frontal setulae. First flagellomere subcircular, compressed. Clypeus shallow, but anteriorly prominent; proboscis elongate, with small apparently membranous labella.

*Thorax* somewhat elongate; scutellum without setulae, shape somewhat resembling that of *Neorhinotora aristalis* (Fischer) (Figs 6,7), with slight longitudinal ridge on each side of dorsal channel, concavity on each side between anterior and posterior bristles, and slightly bigibbous apex; prosternum narrow, weakly sclerotised. Chaetotaxy: 1 humeral, 2 notopleurals, 1

supra-alar, 1 postalar, 1 posterior inter-alar, 1 posterior dorsocentral, 2 scutellars; acrostichal, proepisternal, and anepisternal bristles absent; katapisternum with 2 widely spaced bristles and long setulae. Males with mollisetae (see D. McAlpine [1991: 31] for definition) on ventral surface of katapisternum, metasternum, mid and hind coxae, and ventral surface of fore femur; hind trochanter simple (lacking brushed tubercle, present in males of *Zentula* species). Fore femur with several dorsal bristles; mid femur with several anterior bristles near and beyond middle; male mid femur with small socket-based ovoid anteroventral peg just beyond basal third; hind femur with few dorsal bristles and rather dense ventral setulae; male hind femur stout, apparently raptorial; female hind femur broad, longer than mid femur; fore and hind tibiae shorter than femora, slightly curved with subangular basal thickening; mid tibiae with several short, thick ventroapical spur-like bristles, among which one (female) or 2 (male) form longer spurs; all tibiae with large ventroapical bight (only slightly developed in other rhinotorines, presumably enabling tarsus to be sharply flexed ventrally against tibia); fore basitarsus slightly depressed; mid basitarsus subcylindrical; hind basitarsus obliquely compressed; tarsomeres 1–4 of mid leg with ventrolateral comb of stout black bristles. Wing: cell  $r_1$  without supernumerary crossveins.

**Abdomen:** tergites 2–5 with long, silky golden lateral setae; sternite 1 well sclerotised, quadrate, setulose laterally.

**Male postabdomen** (Figs 2,3): protandrial sclerites resembling those of *Cairnsimyia uniseta* D. McAlpine (see D. McAlpine, 1985, fig. 92); tergite 6 reduced, bare, separate from other sclerites; one large spiracle on either side of tergite 6, remaining spiracles absent; small sclerite present on right side of sternite 8; epandrium with long mollisetae; surstylus trilobed, apical lobe with short bristles; ventroapical lobes of hypandrium with dense patch of dark bristles; gonostylus laterally compressed, apically expanded; ejaculatory apodeme slender with T-shaped base; basiphallus forming slender sclerotised rod; distiphallus with complex sclerotisation, anteriorly reflexed; cerci short, rounded, fused anteroventrally, with long dark undulating bristles.

**Female postabdomen:** sternite 6 divided by median desclerotisation; cerci short, slender, well separated and free distally. Two spermathecae on common duct plus slightly smaller spermatheca on separate duct, each with irregular outer envelope and subspherical, almost smooth black cuticular lining (Fig. 8); black pigment decurrent for short distance on lining of duct; duct deeply inserted into vesicle (at least in single spermatheca, paired ones too intensely pigmented to enable interpretation of internal structure), with cellular (?muscular) envelope in part much thickened

proximally to vesicle. Egg whitish, elongate-ovoid, roughly bilaterally and biterminally symmetrical, except for slight impression at one end from which a small cup-shaped structure protrudes; surface with numerous prominent longitudinal ridges, over 20 at mid-length, some of them not reaching ends, otherwise apparently without external processes; length 1.2 mm, width 0.44 mm.

**Dimensions:** total length, male (abdomen deflexed) 7.7–7.8 mm, female 9.7 mm; length of thorax, male 4.4 mm, female 4.7 mm; length of wing, male 9.7–9.8 mm, female 10.0 mm.

**Etymology.** The specific epithet “*grandis*” refers to its much larger size compared to species of *Cairnsimyia* and *Zentula*.

### Distribution

This species is known only from the Atherton Tableland, which rises more than 600 m above the coastal plain south-west of Cairns in northern Queensland. The Atherton Tableland is one of a series of temperate areas that represent a mesothermal “archipelago”. Mesothermal refers to a plant group with optimum temperatures for growth of 19–22°C (Nix, 1991). In northern Queensland, tropical and subtropical lowlands separate the tablelands (or mesothermal “islands”) from similar mesothermal areas of montane New Guinea and southern Australia. These mesothermal environments of northern Queensland represent regions of high endemism in both vertebrates (Nix, 1991) and invertebrates.

Of the five other heleomyzid species known from the Atherton Tableland (including the less elevated Kuranda district) only one, *Diplogeomyza immaculata* D. McAlpine, appears to be endemic (D. McAlpine, 1967). Three others, *Diplogeomyza tridens* D. McAlpine, *D. signata* D. McAlpine, and *Cairnsimyia cavifrons* Malloch, extend from the Atherton Tableland southwards into New South Wales. *Pentachaeta* sp. (undescribed “sp. E” in AMS) extends from Kuranda, at the northern edge of the Tableland, south to the Clarke Range–Eungella district (c. 21°10'S), and is thus probably restricted to mesothermal areas of the tropics. Other *Pentachaeta* species are restricted to temperate Australia.

### Biology

Specimens from Mount Edith Road were collected in a banana baited fly trap, suspended approximately 1.5–2 m above the ground in upland rainforest. The fly trap is similar to a lobster trap, consisting of a nylon mesh cylinder, with bait suspended near the bottom. The insects are caught alive and removed from the trap using an aspirator.

### Comparative notes

*Zinza* conforms to the description of the tribe Rhinotorini (D. McAlpine, 1985) except that the arista is long-plumose and inserted slightly closer to the base than to the apex of first flagellomere. Within this tribe, *Zinza* belongs in subtribe 1 as characterised by D. McAlpine (1985: 232–233), although the description must be extended to include forms without scutellar setulae (Figs 5–7). This subtribe includes the two other Australian genera *Cairnsimyia* and *Zentula*, whereas subtribes 2 and 3 include only New World taxa.

The distinctive subtruncate, dorsally channelled scutellum resembles that of the Neotropical rhinotorine genus, *Neorhinotora* Lopes (Fig. 6). In addition,  $M_1$  is also strongly curved forward distally to meet  $R_{4+5}$  in the Chilean genus *Mayomyia* Malloch (Malloch, 1934, fig. 11). However, *Zinza* is only distantly related to these two genera, the latter genus belonging in a distinct tribe (Mayomyiini).

The small ventral peg on the mid femur of *Zinza* has not been observed in other rhinotorine taxa, and is male-restricted. As in many other schizophoran flies, mollisetae in this genus are much less developed in females.

Hennig (1958) recorded two spermathecae for *Rhinotora pluricellulata* Schiner (sic), and J. McAlpine (1987) described and figured two spermathecae for *Neorhinotora diversa* (Giglio-Tos). As two and three are both frequent spermathecal counts in Heleomyzidae (four in some *Suillia* species), and as both numbers are present in the tribes Heleomyzini and Allophylopsini (Hennig, 1958; Schneider, 1982; pers. obs. D. McAlpine), it is not surprising that this variation should be present in Rhinotorini. The egg of *Zinza grandis* differs greatly from those of *Rhinotora* and *Neorhinotora* as figured by Lopes (1935, figs 1–3).

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## Deep-water Decapod Crustacea from Eastern Australia: Lobsters of the Families Nephropidae, Palinuridae, Polychelidae and Scyllaridae

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**ABSTRACT.** Twenty-three species of deep-water lobsters in the families Nephropidae, Palinuridae, Polychelidae and Scyllaridae are recorded from the continental shelf and slope off eastern Australia. Ten species and two genera have not been previously recorded from Australia. These are *Acanthacaris tenuimana*, *Projasus parkeri*, *Polycheles baccatus*, *P. euthrix*, *P. granulatus*, *Stereomastis andamanensis*, *S. helleri*, *S. sculpta*, *S. suhmi* and *Willemoesia bonaspei*. The deep-water lobster fauna of eastern Australia is compared with those of other Indo-Pacific areas. A key is given to all deep-water lobster species recorded from Australian waters.

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The deep-water lobster fauna of the Australian region first became known from collections made by the British *Challenger* Expedition (Bate, 1888), the 1911–14 Australasian Antarctic Expedition (Bage, 1938), the Commonwealth of Australia fishing experiments on the *Endeavour* (1909–1914); various local trawling excursions (e.g., Grant, 1905) and serendipitous catches by professional fishermen (e.g., McNeill, 1949, 1956). Knowledge of the fauna has increased greatly since then, especially as commercial fisheries interest and abilities have extended to greater depths. Surveys by Australia's CSIRO on the North West Shelf of Australia, prompted by interest in natural gas resources and potential commercial fisheries, have added many species to the known fauna. Similar surveys in north-east Queensland and New South Wales waters have produced an extensive by-catch of deep-water crustaceans. The deep-water

fauna of southern Australia is as yet poorly known but extensive collections have been made by the Museum of Victoria on the continental shelf and slope of south-eastern Australia and Bass Strait.

This paper is the third of a series dealing with deep-water decapods taken by the New South Wales Fisheries Research Vessel *Kapala*, which has carried out trawling experiments along the coast of New South Wales since 1971. Previous papers dealt with brachyuran crabs (Griffin & Brown, 1976) and shrimps and prawns (Kensley, Tranter & Griffin, 1987). This paper also deals with material from the collections of the Queensland Museum and other Australian Museum material.

The present report gives an account of twenty-three species in four families: Nephropidae, Palinuridae, Polychelidae and Scyllaridae. Species of two other deep-water lobster families have been reported from Australia:



*Neoglyphea inopinata* Forest & de Saint Laurent, 1975, in the family Glypheidae, has been recorded from the Arafura Sea, off north-western Australia (Bruce, 1988b; Forest, 1989) and *Thaumastochelopsis wardi* Bruce, 1988a, in the family Thaumastochelidae, has been recorded from the Marian Plateau, Coral Sea, off north-eastern Australia (Bruce, 1988a).

Material is deposited in the Australian Museum, Sydney (AM) and the Queensland Museum, Brisbane (QM). Measurements given are carapace length (cl.) unless otherwise stated. For the Polychelidae the arrangement of spines along the lateral edge of the carapace is denoted as in this example: 5-6:3-4:7-8 meaning 5 or 6 spines in front of the anterior branch of the cervical groove, 3 or 4 between the anterior and posterior branches of the cervical groove and 7 or 8 behind the posterior branch of the cervical groove. For species of *Stereomastis* the arrangement of spines on the mid-dorsal carina of the carapace is denoted as in this example: 1,1,2,1 meaning two single, one pair, one single spine between the rostral spines and the cervical groove; and 2,2,2 meaning three sets of paired spines behind the cervical groove, including the widely spaced pair on the posterior margin. The terminology of Holthuis (1975) is used for the Nephropidae.

### Family NEPHROPIDAE

#### *Acanthacaris* Bate, 1888

The genus contains two species, one of which is known from the Indo-West Pacific region. The genus has not previously been reported from Australian seas.

#### *Acanthacaris tenuimana* (Bate)

*Phoberus tenuimanus* Bate, 1888: 171.

*Acanthacaris tenuimana*.—Bate, 1888: pl. 21.—Holthuis, 1975: 752.—Hayashi & Ogawa, 1985: 220, fig. 1.—Macpherson, 1990: 293.—Holthuis, 1991: 28, figs 39b, 42.

*Acanthacaris tenuimana*.—Bate, 1888: pl. 22.

*Acanthacaris tenuimanus*.—Bruce, 1974: 303, figs 1,2.

*Phoberus caecus sublevis* Wood-Mason in Wood-Mason & Alcock, 1891: 197.—Alcock & Anderson, 1894: 161.—Anderson, 1896: 96.

*Phoberus caecus tenuimanus*.—Alcock, 1901: 156.—Alcock & McArdle, 1903: pl. 60.

*Acanthacaris opipara* Burukovsky & Musij, 1976: 1811, figs 1,2.

*Phoberus brevirostris* Tung & Wang, 1985: 379, fig. 1.

**Material examined.** One ovigerous female, cl. 157 mm, 1 male, cl. 119 mm, AM P38504, east of Brisbane, south-east Queensland, trawled, 700–900 m, W. Dall on MV *Valkyrie Voyager*, May 1988.

**Remarks.** There is only one first cheliped present, from the female specimen. The fingers are 1.7 times the length of the palm. The rostrum has one pair of small

lateral spines just before the spine-like tip and 5 small anteriorly-projecting spines on the ventral surface of the distal half.

**Distribution.** Indo-West Pacific Ocean: Natal, Mozambique, Madagascar, Laccadive Islands, Japan, Philippines, South China Sea, Indonesia, eastern Australia, New Caledonia; 600–2161 m.

#### *Metanephrops* Jenkins, 1972

The genus contains 17 recent species, of which 15 are known from the Indo-West Pacific region. Five species have been recorded from Australian waters: *Metanephrops australiensis* (Bruce, 1966a) from north-western Australia (Bruce, 1966a; George, 1983; Carter *et al.*, 1983; Anon., 1984; Wallner & Phillips, 1988; Wassenberg & Hill, 1989); *M. boschmai* (Holthuis, 1964) from north-western and southern Australia (Holthuis, 1964); *M. neptunus* (Bruce, 1965a) from north-western Australia (George, 1983; Holthuis, 1991; Wadley & Evans, 1991); *M. sibogae* (de Man, 1916) from north-western and north-eastern Australia (Holthuis, 1991; Wadley & Evans, 1991) and *M. velutinus* Chan & Yu, 1991 from north-western Australia (George, 1983; Anon., 1984; Davis & Ward, 1984; Bremner, 1985; Wallner & Phillips, 1988; Wassenberg & Hill, 1989; all as *M. andamanicus* [Wood-Mason, 1892]) and from southern Australia (Chan & Yu, 1991).

#### *Metanephrops sibogae* (de Man)

*Nephrops Sibogae* de Man, 1916: 102, pl. 4 figs 18–18d.—Bruce, 1966b: 165 (key).

*Metanephrops sibogae*.—Jenkins, 1972: 163, 171.—Holthuis, 1991: 65, figs 113c, 127b, 154.—Wadley & Evans, 1991: 36, unnumbered figs.

**Material examined.** Two males, cl. 58 mm and 38+ mm (rostrum broken), QM W11219, east of Murray Isles, Coral Sea, 9°50'S 144°11'E to 9°51'S 144°09'E, 460–464 m, *Gwendoline May*, 27 May 1983; 1 female, cl. 48+ mm (tip of rostrum broken) and 1 male, cl. 40 mm, QM W11725, east of Murray Isles, Coral Sea, 480 m, *Gwendoline May*, 28 May 1983; 1 male, cl. 77 mm, AM P45097, east of Cape York, Coral Sea, 10°29.81'S 144°01.38'E, beam trawl, 596–603 m, P. Hutchings & party on RV *Franklin*, 20 August 1988, stn FR0688–2.

**Remarks.** *Metanephrops sibogae* has until recently been known only from the type material, nine specimens from near the Kei Islands, Indonesia. Holthuis (1991) indicated additional collections from northern Australia, but without comment or description. Wadley & Evans (1991) recorded the species from north-western Australia. The present material agrees well with de Man's (1916) description and figure of *M. sibogae* except in a few points which support the very close relationship between *M. sibogae* and *M. boschmai* (Holthuis, 1964) from the Great

Australian Bight. Type material of *M. boschmai* has been examined and compared to the present Coral Sea material and the published description and figures of *M. sibogae*. The following points of difference/correspondence were noted:

1. *Metanephrops boschmai*, *M. sibogae* and the Coral Sea material all have a set of 3 spines behind the orbit (the supraorbital, post supraorbital and postorbital spines in the terminology of Holthuis [1975]). Above the spines; *M. boschmai* has a patch of 1–4 very small spinules. These are absent in the Coral Sea specimens, but a similar patch of very small spinules occurs more posteriorly, between the cervical spine and the median carina. Neither of these patches of spinules is described or illustrated for *M. sibogae*.

2. *Metanephrops boschmai* has 4–7 spinules along the posterior margin of the cervical groove, between the cervical and hepatic spines. These are not present in *M. sibogae* or the Coral Sea specimens.

3. *Metanephrops sibogae* has 6–7 pairs of denticles along the medial carina of the branchial area, posterior to the pair of post cervical spines; *M. boschmai* has 3–5 pairs of denticles and the Coral Sea specimens have three pairs.

4. The sixth abdominal somite of *M. sibogae* has four spinules arranged as in the four points of a cross, i.e. one anterior median spinule, two submedian spinules behind this and one posterior median spinule (clearly seen in de Man, 1916, plate 4, figure 18). This arrangement of spinules is also found in the Coral Sea specimens, but in *M. boschmai* the anterior spinule is absent and there are often two, sometimes three, sub median pairs.

5. Holthuis (1964) suggested that *M. boschmai* differs from *M. sibogae* in that the greatest breadth of the scaphocerite is in the proximal half in *M. boschmai* but in the distal half in *M. sibogae*. Comparison of figure 1 of Holthuis (1964), plate 4, figure 18b of de Man (1916) and available material suggests that the differences in this character are so slight as to be not of specific value.

6. The dactylus of the third maxilliped is slightly broader in *M. boschmai* than in *M. sibogae* or the Coral Sea material.

7. The merus of pereopod 1 has, in *M. boschmai*, a distinct tooth in the middle of the inner margin, sometimes followed by one or more much smaller teeth. In *M. sibogae*, de Man (1916: 106) described the merus as having "usually 2 or 3, rarely 4 or 5, granules of the inner margin ... a little larger than the rest and more or less spiniform." The two larger males from the Coral Sea (QM W11219) have two and three (on the left and right respectively) slender spinules on the inner margin of the merus. The two smaller specimens each have only one first pereopod present, which have two similar spinules.

8. De Man (1916) recorded a sharp tooth on the inner margin of the carpus of pereopod 1 on both sides of one specimen and on the right side only of three other specimens (but not present on the specimen in figure

18 of plate 4). He referred to this spine as "an abnormality" and "the accidental spine". This strong tooth is present on both sides of the larger Coral Sea specimens and on the two first pereopods of the smaller specimens. It is absent in *M. boschmai*.

9. The Coral Sea specimens have a distinct tooth about the middle of the inner margin of the propodus of pereopod 1. In *M. sibogae* this margin is described as granulose and in *M. boschmai* it is quite smooth.

10. The propodus of pereopod 1 is relatively broader in *M. sibogae* and the Coral Sea specimens than in *M. boschmai*; in *M. sibogae* it is broadest at the level of articulation of the dactylus whereas in *M. boschmai* the broadest point is midway between the proximal end of the propodus and the articulation of the dactylus.

**Distribution.** Indo-West Pacific Ocean: Indonesia, northern Australia, Coral Sea; 260–480 m. It is possible that some of the material recorded as *M. boschmai* from the North West Shelf of Australia may be *M. sibogae*.

### *Metanephrops velutinus* Chan & Yu

*Nephrops andamanicus*.—Holthuis, 1964: 71.

*Metanephrops andamanicus* (sensu Holthuis, 1964).—Jenkins, 1972: 162, 171.—Chan & Yu, 1987: 184 (key).

*Metanephrops andamanicus*.—Carter *et al.*, 1983: 2, 4.—Anon., 1984: 46.—Davis & Ward, 1984: 42.—Bremner, 1985: 39, graphs 1, 2, fig. 3.—Ward & Davis, 1987: 93.—Wallner & Phillips, 1988: 36, graphs 2, 3.—Macpherson, 1990: 294, figs 2c,d, 3c,d.

[?] *Nephrops andamanicus*.—de Man, 1916: 99, pl. 3 fig. 15. *Metanephrops velutinus* Chan & Yu, 1991: 22 (key), 35, pls 2b, 4b, 6c, 8a,c,d.—Holthuis, 1991: 64 (key), 82, figs 121, 160.—Wadley & Evans, 1991: 37, unnumbered figs.

Not *Nephrops andamanicus* Wood-Mason, 1892.

**Material examined.** One male, cl. 70+ mm (rostrum broken at mid-eye level), QM W11212, east of Murray Isles, Torres Strait, 9°51'S 144°26'E to 9°53'S 144°23'E, 480 m, trawled, RV *Gwendoline May*, 28 May 1983; 1 ovigerous female, cl. 67.5 mm, QM W14388, east of Murray Isles, Torres Strait, trawled, RV *Gwendoline May*, 28 May 1983.

**Remarks.** The cervical (or upper hepatic) spine is absent in both specimens; there is no branchial spine at the anterior end of the branchial carina; and the intermediate carinae are not granulose.

**Distribution.** Indo-West Pacific Ocean: Philippines, north-eastern and western to southern Australia (Torres Strait to Great Australian Bight); 238–702 m.

### *Nephropsis* Wood-Mason, 1873

The genus contains 16 species, of which 10 are known from the Indo-West Pacific region. Six species have been previously recorded from Australian seas: *Nephropsis acanthura* Macpherson, 1990, from north-eastern

Australia (Macpherson, 1990) and western Australia (Macpherson, 1993); *N. holthuisi* Macpherson, 1993, from north-western Australia (Macpherson, 1993); *N. serrata* Macpherson, 1993, from north-western Australia (Wadley & Evans, 1991, as *Nephropsis* sp. 1; Macpherson, 1993); *N. stewarti* Wood-Mason, 1873, from north-western Australia (George, 1983; Wadley & Evans, 1991; Macpherson, 1993) and north-eastern Australia (Macpherson, 1993); *N. suhmi* Bate, 1888, from north-western Australia (Macpherson, 1993) and north-eastern Australia (Macpherson, 1990); and *N. sulcata* Macpherson, 1990, from north-western Australia (Macpherson, 1993) and north-eastern Australia (Macpherson, 1990; 1993).

### *Nephropsis acanthura* Macpherson

*Nephropsis acanthura* Macpherson 1990: 302 (key), 311, figs 5d, 9d-f, 11a,b, 16d.-Holthuis, 1991: 32 (key), 35, fig. 61.-Macpherson, 1993: 55, 64 (key).

**Material examined.** One male, cl. 30 mm, AM P39685, east of Cape Hawke, 32°08'S 153°09'E to 32°04'S 153°10'E, 1033-1080 m, 15 June 1989, FRV *Kapala*, stn K89-12-04; 2 males, cl. 42 and 44 mm, AM P40378, east of Newcastle Bight, 32°50'S 152°50'E, 1090-1134 m, 11 April 1989, FRV *Kapala*, stn K89-06-04; 1 female, cl. 36 mm, AM P40379, north-east of Port Hunter, 32°05'S 152°50'E, 1079-1097 m, 8 June 1989, FRV *Kapala*, stn K89-11-01; 1 female, cl. 42.5 mm, AM P40380, east of Port Hunter, 32°55'S 152°45'E, 1043-1061 m, 11 April 1989, FRV *Kapala*, stn K89-06-02; 1 male, cl. 52 mm, AM P40381, east of Port Hunter, 33°02'S 152°38'E, 896-960 m, 16 May 1989, FRV *Kapala*, stn K89-09-01; 1 female, cl. 37 mm, AM P39233, south-east of Port Hunter, 33°05'S 152°33'E to 33°04'S 152°36'E, 896-951 m, 5 May 1988, FRV *Kapala*, stn K88-08-08; 1 male, cl. 45 mm, AM P39234, south-east of Port Hunter, 33°07'S 152°33'E to 33°06'S 152°38'E, 1006-1080 m, 3 May 1988, FRV *Kapala*, stn K88-08-02; 1 female, cl. 41 mm, 1 male, cl. 45 mm, AM P39235, east of Broken Bay, 33°33'S 152°09'E to 33°35'S 152°08'E, 1022-1051 m, 19 December 1985, FRV *Kapala*, stn K85-21-04; 1 ovigerous female, cl. 52+ mm (rostrum broken), AM P39236, east of Broken Bay, 33°36'S 152°01'E to 33°32'S 152°05'E, 722-759 m, 25 September 1984, FRV *Kapala*, stn K84-16-04; 1 ovigerous female, cl. 42 mm, AM P40382, east of Broken Bay, 33°37'S 152°06'E, 990-1020 m, 17 October 1983, FRV *Kapala*, stn K83-13-01; 1 female, cl. 46 mm, AM P40383, east of Broken Bay, 33°37'S 152°07'E, 1024-1088 m, 18 May 1989, FRV *Kapala*, stn K89-09-07; 1 female, cl. 50 mm, AM P40384, east of Broken Bay, 33°45'S 152°03'E, 1005-1015 m, 11 October 1984, FRV *Kapala*, stn K84-18-07; 1 female, cl. 46+ mm (rostrum broken), AM P40385, east of Shoalhaven Heads, 34°50'S 151°15'E, 988-1015 m, 26 October 1983, FRV *Kapala*, stn K83-14-04; 1 male, cl. 48 mm, AM P44030, east of Ulladulla, 35°27'S 150°54'E, 1050-1105 m, 14 December 1988, FRV *Kapala*, stn K88-22-01; 1 male, cl. 43 mm, AM P39237, north-east of Batemans Bay, 35°32'S 150°51'E to 35°27'S 150°55'E, 988-1024 m, 4 August 1988, FRV *Kapala*, stn K88-14-04.

**Remarks.** Most of these specimens are considerably larger than the type specimens (16-36 mm) but agree well with Macpherson's description. The post supraorbital

spines vary in number and position from none at all, to only one on either the right or left side, to two on each side.

**Distribution.** Indo-West Pacific Ocean: Madagascar, Philippines, north-western and eastern Australia, Tasman Sea, Coral Sea, Chesterfield Islands, New Caledonia; 720-1305 m.

### *Nephropsis holthuisi* Macpherson

*Nephropsis holthuisi* Macpherson, 1993: 55, figs 1-3 (but not fig 3B), fig. 6B (erroneously as *N. serrata*).

**Material examined.** One male, cl. 40 mm, AM P44029, east of Terrigal, 33°33'S 152°10'E, 1080-1135 m, trawled, 31 August 1988, FV *Kapala*, stn K88-17-04.

**Remarks.** This specimen differs in some small ways from the type material, but is sufficiently similar to be included in the species. The rostrum is not horizontal but has a slight sinusoidal curvature. There are four (left) and three (right) small spines at the proximal end of the subdorsal carinae and the same number of small postsupraorbital spines. The antennal spines are about the same size as the supraorbital spines. Except for the lateral carina the carinae on the posterior carapace are not well developed. The pleuron of the second abdominal segment ends in a longer and sharper point than that of the holotype. The pleuron of the sixth abdominal segment ends in a short sharp double point. The coxal process on the second pereopod is bluntly pointed rather than rounded.

**Distribution.** Indo-West Pacific Ocean: north-western Australia (Ashmore Reef), eastern Australia; 900-1105 m.

### *Nephropsis suhmi* Bate

*Nephropsis suhmi* Bate, 1888: 181, pl. 23 fig. 3, pl. 24 fig. 2.-Anderson, 1896: 96.-Ramadan, 1938: 125 (in part).-Macpherson, 1990: 302 (key), 306, figs 5b, 7d-f, 8c,d, 16b.-Holthuis, 1991: 35 (key), figs 60, 82.-Macpherson, 1993: 64 (key).

*Nephropsis Suhmi*.-Alcock, 1901: 158 (key), 163.-de Man, 1916: 97, 112 (key), 114.-Bouvier, 1917: 21 (key).-Balss, 1925: 208.

**Material examined.** One male, cl. 42.5 mm, AM P39699, Lord Howe Rise, western Tasman Sea, 27°39.8'S 161°46.3'E, beam trawl, 1423 m, J.K. Lowry *et al.* on RV *Franklin*, 6 May 1989, stn FR 0589-31.

**Remarks.** There are two postsupraorbital spines present on each side of the carapace. There is a well-developed spine on the anterior margin of pleura of abdominal segments 2 to 4 (as in the holotype), but not on segment 5 (as in Macpherson's material).

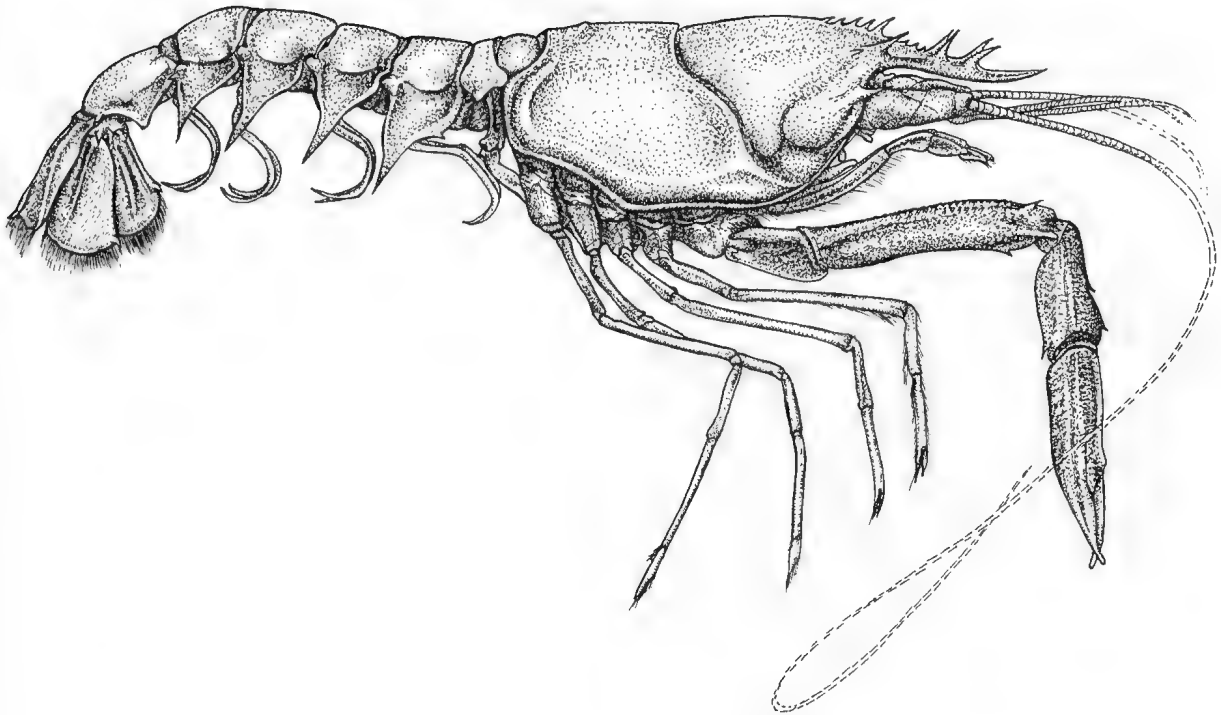


Fig. 1. *Nephropsis sulcata* Macpherson, male, cl. 38 mm, AM P20990, lateral view.

**Distribution.** Indo-West Pacific Ocean: Madagascar, Arabian Sea, Maldiv Islands, Indonesia, north-western and north-eastern Australia, western Tasman Sea, New Caledonia; 786-2029 m.

*Nephropsis sulcata* Macpherson

Fig. 1

*Nephropsis atlantica*.—Wood-Mason & Alcock, 1891: 197, fig. 4.—Alcock, 1894a: 230.—Alcock & Anderson, 1894: 162.—Anderson, 1896: 96.—Alcock, 1901: 158 (key), 161.—Stebbing, 1902: 34.—Stebbing, 1910: 379.—Barnard in Gilchrist, 1918: 48.—von Bonde, 1932: 59.—von Bonde & Marchand, 1935: 6.—Barnard, 1950: 530, fig. 99b-e.—Barnard, 1964: 12.—Bruce, 1966c: 223.—Kensley, 1981: 29. (Not *Nephropsis atlantica* Norman, 1882).

*Nephropsis sulcata* Macpherson, 1990: 303 (key), 319, figs 13e-g, 14a,b, 15a,b, 16g.—Holthuis, 1991: 34 (key), 47, figs 58,84.—Macpherson, 1993: 64,65 (key).

**Material examined.** One female, cl. 39.5 mm, QM W14382, mid-eastern Queensland, 23°17'S 153°56'E, 732 m, trawled, M.V. *Southern Intruder*, 29 November 1983; 1 male, cl. 37.5 mm, QM W11394, mid-eastern Queensland, 24°30'S 153°30'E, 658 m, trawled, M.V. *Southern Intruder*, 2 October 1983; 1 ovigerous female, cl. 39 mm, AM P38495, east of Brisbane, south-eastern Queensland, 700–900 m, trawled, M.V. *Valkyrie Voyager*, May 1988; 1 male, cl. 38 mm, AM P20990, 1 male, cl. 26+ mm (rostrum broken), AM P20997, east of Broken Bay, 33°32'S 152°00'E to 33°38'S 152°04'E, 810 m, 19 August 1975, FRV *Kapala*, stn K75-05-05; 1 ovigerous female, cl.

45 mm, AM P19098, north-east of Port Jackson, 33°43'S 151°57'E to 33°40'S 151°59'E, 765 m, 6 December 1972.

**Remarks.** One specimen (39 mm female, AM P38495) has a third lateral spine on the right side of the rostrum, close to the base and about halfway between the second rostral spine and the supraorbital spine. This is also the only specimen in which the median rostral groove overreaches the anterior pair of rostral spines. In the other specimens the groove extends only to the base of the anterior pair of spines. There are 4 or 5 small spines at the proximal end of each subdorsal carina, between the supraorbital spine and the gastric tubercle. One specimen (45 mm female, AM P19098) has 2 additional small spines anterior to the largest spine which is level with the supraorbital spine. In all specimens the median and intermediate carinae are absent or very poorly defined; the lateral carina is strong. There is only one small spine on the anterior margin of the pleura of abdominal segment 2.

**Colour.** (Based on AM P20990) Posteromedian part of carapace and abdominal terga (pubescence) grey-green; rostrum, rostral and other spines, entire edge of carapace and abdominal pleura pale red, tips of all spines and tips of pleurae white; antennular and antennal flagella, maxillipeds, pereopods 2 to 5, all pleopods, uropods and distal portion of telson brilliant red; peduncles of antennae white; eye peduncles bright red with cornea white; chelipeds (pubescence) greenish-yellow with fingers of propodus reddish with white tips.

**Distribution.** Indo-West Pacific Ocean: southern Africa (Natal), south-western Indian Ocean (Madagascar), Laccadive Sea, South China Sea, Philippines, north-western and eastern Australia, Coral Sea, Chesterfield Islands, New Caledonia; 415–1115 m.

### Family PALINURIDAE

#### *Linuparus* White, 1847

The genus contains three recent species, all of which occur in the Indo-West Pacific region. Two species have been previously recorded from Australian waters: *Linuparus sordidus* Bruce, 1965b, from north-western Australia (George, 1983; Wadley & Evans, 1991) and *L. trigonus* (von Siebold, 1924) from north-western Australia (George, 1983; Wadley & Evans, 1991), north-eastern Australia (Wassenberg & Hill, 1989) and south-eastern Australia (McNeill, 1949, 1953, 1956; Berry & George, 1972).

#### *Linuparus sordidus* Bruce

*Linuparus sordidus* Bruce, 1965b: 1, fig. 1A, pls 1, 2A, C.–Berry & George, 1972: 18 (key), 22.–George, 1983: 16, 19 (key), 20.–Williams, 1986: 15, fig. 32.–Williams, 1988a: 64, unnumbered fig.–Chan & Yu, 1989c: 290, pl. 1A.–Holthuis, 1991: 111 (key), 113, figs 209a, 210a, 213.–Wadley & Evans, 1991: 29, unnumbered figs.

**Material examined.** Three females, cl. 71–87 mm, AM P44028, north-east of Danger Point, 28°02'S 153°57'E, 410 m, 1 June 1978, FRV *Kapala*, stn K78-09-02; 5 females, cl. 73–85 mm, AM P21667 to P21671, 1 male, cl. 62 mm, AM P21672, south-east of Clarence River, 29°41'S 153°45'E to 29°32'S 153°47'E, 399–406 m, 10 October 1975, FRV *Kapala*, stn K75-09-04.

**Remarks.** These specimens have all the features characteristic of *L. sordidus*, including colour: dirty-yellow brown except for the bright orange-red distal two thirds of the antennal flagella. Three specimens have a small secondary spinule on the medial slope of either the left or right supraorbital horn.

Berry & George (1972) used the presence of vestigial pleopods on the first abdominal segment to differentiate *L. somniosus* from *L. trigonus* and *L. sordidus*. In the present material one female (AM P21667) has on the right side a single reduced pleopod of a form different from that figured by Berry & George. In this specimen the antennular peduncle reaches barely as far forward as the tip of the antennal peduncle rather than extending well beyond.

There are no distinct dorsal spines on abdominal segments 2 or 3 and, except in the single male, no submedial spines on the sterna of abdominal segments 2 to 5. Ornamentation of the abdominal segments and sternum may vary with size of the animal.

**Distribution.** South China Sea, Taiwan, north-western and eastern Australia; 200–414 m.

#### *Linuparus trigonus* (von Siebold)

*Palinurus Trigonus* von Siebold, 1824: 15.

*Palinurus trigonus*.–De Haan, 1841: 157, pls 39, 40.–Yamaguchi, 1993: 588.

*Linuparus trigonus*.–Holthuis, 1946: 121, pl. 11 figs ij.–McNeill, 1953: 89.–McNeill, 1956: 53, unnumbered fig.–Bruce, 1965b: 13, fig. 1B, pl. 2B, D.–Holthuis, 1966: 264.–Prasad & Tampi, 1969: 79.–Holthuis & Sakai, 1970: 92, 114, pl. 6.–Berry & George, 1972: 18 (key), 21.–George, 1983: 17, 18 (unnumbered fig.), 19 (key), 20.–Williams, 1986: 15, figs 7a, 31.–Williams, 1988a: 63, unnumbered fig. & photo.–Wassenberg & Hill, 1989: 161.–Holthuis, 1991: 111 (key), 114, figs 210b, 215.–Wadley & Evans, 1991: 30, unnumbered figs.–Ng, 1992: 184.–Yamaguchi & Baba, 1993: 238, figs 54A–C, pl. 5b, c.

Not *Linuparus trigonus*.–Barnard, 1950: 820 (= *L. somniosus* Berry & George, 1972).

*Puerulus carinatus*.–McNeill, 1949: 337, unnumbered fig. (Not *Puerulus carinatus* Borradaile, 1910).

**Material examined.** One female, cl. 64.5 mm, AM P17914, north-east of Wooli, 29°51'S 153°40'E to 29°58'S 153°38'E, 315 m, prawn trawl on sandy mud, 11 May 1971, FRV *Kapala*, stn K71-09-03; 1 female, cl. 99 mm, AM P44026, east of Newcastle, 32°53'S 151°59'E to 32°53'S 152°00'E, 71–73 m, 10 April 1990, FRV *Kapala*, stn K90-07-07; 1 female, cl. 47 mm, AM P44027, east of Long Reef, 33°45'S 151°30'E, 121–122 m, 19 March 1986, FRV *Kapala*, stn K86-06-07.

**Colour.** Bright red with yellow-brown patches.

**Distribution.** Western Pacific Ocean: Japan, Korea, China, Taiwan, Vietnam, Philippines, north-western and eastern Australia; 30–414 m.

#### *Projasus* George & Grindley, 1964

The genus contains two species, one of which is known from the Indo-West Pacific region. Adults of the genus have not previously been reported from Australian waters, though Webber & Booth (1988) reported a puerulus stage of *Projasus* sp. from east of Greenwell Point, New South Wales.

#### *Projasus parkeri* (Stebbing)

*Jasus parkeri* Stebbing, 1902: 39, pl. 7.–Stebbing, 1910: 375.–K.H. Barnard, 1950: 540.

*Puerulus parkeri*.–Holthuis, 1946: 110, 148.

*Projasus parkeri*.–George & Grindley, 1964: 89, fig. 2.–George, 1976: 31.–Webber & Booth, 1988: 82, figs 1–3.–Melville-Smith, 1990: 314.–Holthuis, 1991: 158 (key), 159, figs 295b, 298.

**Material examined.** One female, cl. 53.5 mm, AM P45094, east of Newcastle, 33°30'S 152°10'E, 880 m, G. Harmer, 1992;

1 female, cl. 69.8 mm, 1 male, cl. 64.2 mm, AM P45096, east of Bermagui, 36°23'S 150°22'E, 820 m, J. Jarvis on FV *Josephine Jeen*, 3 December 1993; 1 male, cl. 63.2 mm, AM P41898, east of Eden, 37°35'S 150°21'E, 810 m, D. Bradbury on MV *Pacific Dynasty*, 25 May 1993; 1 male, cl. 64.4 mm, AM P45095, south-east of Gabo Island, 37°40'S 150°19'E, 730 m, M. Kelly on FV *Terrance Star*, 1 December 1993.

**Remarks.** These five specimens differ slightly from the South African material described by George (1976) and show much of the variation noted by Webber & Booth (1988) in their New Zealand material. In particular, the rostrum curves upward or is straight; the anterior margins of the supraorbital horns are almost straight in some specimens but slightly convex in others; the branchial spine row is curved in lateral view; the median carina of abdominal segment 1 varies from a distinct carina with a small sharp anterodorsally-directed tooth to almost absent with a very small blunt tooth; the median carina of abdominal segments 2 to 5 is low, blunt and anteriorly obtuse. There are two median spines on the posterior margin of the fifth sternal plate and no median posterior spine on the fourth abdominal segment. The 53.5 mm female (AM P45094) has two distinct teeth on the anterior margin of the first abdominal pleurite; the other specimens have 3–5 blunt granules.

The discovery of adult *Projasus parkeri* on the east coast of Australia makes it highly likely that the puerulus stage described by Webber & Booth (1988), as *Projasus* sp., is really that of *P. parkeri* as they suggested.

**Distribution.** Atlantic Ocean: south-west Africa; Indian Ocean: south-east Africa, St Paul Island; Pacific Ocean: south-eastern Australia, New Zealand; 370–880 m.

### *Puerulus* Ortmann, 1897

The genus contains four species, all of which occur in the Indo-West Pacific region. Two species have been previously recorded from Australian waters: *Puerulus angulatus* (Bate, 1888), from north-western Australia (George, 1983; Wadley & Evans, 1991) and *P. velutinus* Holthuis, 1963, also from north-western Australia (Wadley & Evans, 1991).

### *Puerulus angulatus* (Bate)

*Panulirus angulatus* Bate, 1888: 81, pl. 11 figs 2–4.

*Puer angulatus*.—Ortmann, 1891: 37.

*Puerulus angulatus*.—Calman, 1909: 442.—Balss, 1925: 203.—Holthuis, 1946: 110.—Holthuis, 1966: 267 (in part, part = *P. carinatus* Borradaile, 1910).—Berry, 1969: 247, pl. 1 fig. 2, pl. 2 fig. 2, pl. 3 fig. 2.—Harada, 1980: 244, figs 1,2.—Kensley, 1981: 30.—George, 1983: 16, 19 (key), 20.—Baba *et al.*, 1986: 155, 282, fig. 106.—Williams, 1986: 25 (key), fig. 59A.—King, 1988: 109.—Williams, 1988a: 111 (key), unnumbered figs.—Williams, 1988b: 315.—Chan & Yu, 1989a: 2, pl. 1.—Holthuis, 1991: 162, figs 300b, 301.—Wadley & Evans, 1991: 31, unnumbered figs.

*Puerulus carinatus*.—Ramadan, 1938: 133, figs 6,7. (Not *Puerulus carinatus* Borradaile, 1910).

*Puerulus gracilis* Kubo, 1939: 316, figs. 1,2.

Not *Panulirus angulatus*.—Alcock & Anderson, 1894: 166.—

Alcock, 1901: 185. (= *Puerulus sewelli* Ramadan, 1938).

Not *Puerulus angulatus*.—de Man, 1916: 36, pl. 2 fig. 5. (= *P. velutinus* Holthuis, 1963).

**Material examined.** One male, cl. 35.8 mm, AM P34714, 2–3 km north-north-east of Raine Island, Queensland, 11°35'S 114°02'E, 275m, prawn trawl over sand, 12 February 1979, FNQ 79-31; 1 ovigerous female, cl. 43.4 mm, 1 male, cl. 43.2 mm, QM W14299, 17°33'S 149°52'E to 17°35'S 149°56'E, 302 m, P. Davie on RV *Soela*, 3 December 1985; 1 ovigerous female, cl. 48.9 mm, 1 male, cl. 40 mm, QM W14270, 17°39'S 150°10'E to 17°36'S 150°10'E, 225 m, P. Davie on RV *Soela*, 4 December 1985; 3 females, cl. 33.5, 37, 38 mm, QM W14383, 22°00'S 153°31'E, 270 m, MV *Southern Intruder*, 1 November 1983; 1 male, cl. 34.8 mm, QM W10163, 22°54.5'S 152°12.5'E, 351 m, CRAIGMIN Survey, 3 December 1980; 1 male, cl. 45.8 mm, QM W14384, 28°05'S 153°54'E, 270 m, P. Dutton on MV *Iron Summer*, 27 July 1982; 1 male, cl. 44.7 mm, QM W14374, 28°05'S, 275m, P. Dutton on MV *Iron Summer*, 27 September 1982; 1 female, cl. 47 mm, 2 males, cl. 24.5 and 38.5 mm, AM P39488, Britannia Sea Mount, western Tasman Sea, 28°18.48'S 155°38.62'E, 415 m, limestone and coarse coral sand bottom, J.K. Lowry & party on RV *Franklin*, 10 May 1989, stn FR0589-48; 1 female, cl. 21.7 mm, AM P26841, east of Wollongong, NSW, 192 m; 1 immature, cl. 13 mm, AM P30647 and 1 female, cl. 30.5 mm, AM P30754, 32 km east of Greenwell Point, NSW, 34°55'S 151°08'E, 373 m and 408 m, A. Bell, 16 July 1980.

**Remarks.** These specimens are generally in good agreement with the description of Holthuis (1966). They differ slightly in the following features: The supraorbital horns are only very slightly crenulate in most specimens and quite smooth in the 47 mm female (AM P39488). The tooth on either side of the anterior margin of the carapace, at the inner base of the supraorbital horn, is single, rather than bifurcate, in all specimens except the 47 mm female. The third tooth of the row between the supraorbital horns and the cervical groove is very small and in some specimens is present on one side only; it is slightly lateral to, and closely pressed against, the base of the second tooth; in a few specimens it is bifurcate or a second tiny tooth is also present. As reported by Berry (1969) for South African material, there is only one row of 4–5 teeth on the ventral surface of antennal segment 3.

Holthuis (1966: 270) mentions that in a 12 mm juvenile from the Philippines, the “epistome, instead of having a single median tooth which is directed forward, has two strong submedian spine-like teeth which are directed ventrally”. In the present material the 13 mm juvenile (AM P30647) and the 21.7 mm female (AM P26841) have both the single median tooth and a blunt submedian tooth on either side of it. These two small specimens also have well-developed median spines on the thoracic sternum, and 1, 1, 2 and 3 spines at the base of pereopods 2, 3, 4 and 5 respectively, as in adults.

This series of specimens shows clearly that the size and sharpness of the spines on the abdominal median



keel decreases with increase in size of the animal. The abdominal profile of the 13 mm juvenile is almost identical to that of Bate's juvenile holotype, but in large adults the spines are reduced to a blunt ridge. The spines at the base of pereopods 2 to 5 are also much less sharp in larger specimens.

**Colour.** (of specimens AM P39488): overall appearance light orange; antennae uniformly light orange, not banded; anterior carapace mottled orange to translucent white, dark orange to red around bases of spines, tips of spines white; pereopods white; dark orange transverse bands on posterior of abdominal somites 1 to 6 and on abdominal carinae.

These colour notes were made from frozen material and colour photographs of that material. Of particular note is that the antennae are not banded. Berry (1969), Holthuis (1991) and Wadley & Evans (1991) have drawn attention to the banded red and white antennae of *P. angulatus*. It is possible that the banding was lost as a result of freezing but this seems unlikely since the remainder of the animal retained good colour. Morphologically, the specimens are unquestionably *P. angulatus*.

**Distribution.** Western Indian Ocean: Natal, Mozambique, Zanzibar, Somalia; Northern Indian Ocean: Nicobar Islands; Western Pacific Ocean: Japan, Philippines, Taiwan, New Guinea, north-western and eastern Australia, western Tasman Sea; 192–536 m.

## Family POLYCHELIDAE

### *Polycheles* Heller, 1862

The genus contains about sixteen species, of which nine are known from the Indo-West Pacific region and a further two from the north central Pacific Ocean. One species has been previously recorded from Australian waters: *Polycheles typhlops* Heller, 1862, from north-western Australia (George, 1983; Wadley & Evans, 1991).

### *Polycheles baccatus* Bate

*Polycheles baccatus* Bate, 1878: 278.—de Man, 1916: 5 (list), 23 (key), 26, pl. 1 figs 4, 4a.—Bernard, 1953: 86.—Firth & Pequegnat, 1971: 39 (key), 41.—Chan & Yu, 1989b: 168, pl. 1C,D.

*Polycheles baccata*.—Bate, 1888: 131, fig. 32, pl. 14 fig. 1.—Sund, 1920: 226.

**Material examined.** One male, cl. 34.5 mm, QM W20794, 27°12.83'S 153°52.87'E, trawled, MV *Iron Summer*, R. Morton, 10 May 1983; 1 male (badly damaged), cl. 25 mm, AM P21766, north-east of Woolli, 29°52'S 153°43'E to

29°46'S 153°45'E, 505 m, 10 October 1975, FRV *Kapala*, stn K75-09-03; 1 female, 33.5 mm, AM P44749, south-east of Cape Byron, 28°37'S 153°50'E, 502 m, 19 August 1978, FRV *Kapala*, stn K78-17-21; 1 female, cl. 43 mm, AM P26649, east of Woolli, 29°51'S 153°43'E, 495 m, 23 August 1977, FRV *Kapala*, stn K77-13-10; 1 male, cl. 36.5 mm, AM P26549, east of Woolli, 29°52'S 153°43'E to 29°55'S 153°42'E, 495 m, 23 August 1977, FRV *Kapala*, stn K77-13-12; 1 ovigerous female, cl. 34.5 mm, AM P40372 and 3 ovigerous females, cl. 40, 40.5, 41.5 mm, AM P44748, north-east of North Solitary Island, 29°53'S 153°42'E to 29°50'S 153°43'E, 457 m, 26 April 1978, FRV *Kapala*, stn K78-06-07.

**Remarks.** The carapaces of these specimens are densely covered with fine and medium-sized granules. There are two rostral spines and immediately below these a conical tooth projects from the frontal wall of the carapace. The frontal border of the carapace bears spines or granules extending just beyond the internal angle of the orbit. In the smallest male (AM P21766) a strong, acute, flattened tooth forms the internal angle of the triangular orbital notch, the rounded external border of which is armed with five to seven spines.

The spine formula of the lateral edge of the carapace is 9–12:5:21–25. The spine forming the anterolateral angle of the carapace is larger than the following lateral spines and, like the others, is inwardly curved. The mid-dorsal carina (excluding rostral spines) comprises paired granules, two pairs anteriorly and several pairs posteriorly being larger than the others. The posterior edge of the carapace is armed with small spinules or raised granules. The gastro-orbital carina is composed of small spinules like those mid-dorsally and the superior branchial carina is marked by a line of raised granules. The two branches of the cervical groove are also marked by a series of raised granules.

The 25 mm male (AM P21766) corresponds more closely to de Man's (1916) description and figures of the *Siboga* material than to Bate's description and figures of the *Challenger* specimen of *P. baccatus*. De Man, however, pointed out several inaccuracies in Bate's description and figures.

**Colour.** (Based on AM P21766). Dorsal surface of the carapace and abdomen a rich burnt orange, area below lateral edges of carapace and lower half of the abdominal pleura white. Interspaces between abdominal segments as well as the grooves in abdominal terga also white. Second to fifth pereopods white, chelae of second and third pereopods pinkish red. Ischium of cheliped pinkish, colour continuing to proximal portion of merus; distal portion of merus, carpus and propodus burnt orange; joints between merus and carpus, carpus and propodus and tips of fingers whitish, giving a subtly banded appearance.

**Distribution.** Indo-West Pacific Ocean: Taiwan, Bali Sea, south-eastern Australia, Fiji; 350–916 m.



*Polycheles euthrix* (Bate)

Figs 2,3

*Pentacheles enthrix* Bate, 1878: 280, pl. 13 figs 1-3 (erroneous spelling for *P. euthrix*).

*Pentacheles euthrix*.-Bate, 1888: 149, figs 33-36, pl. 17.-Sund, 1920: 226.

*Polycheles euthrix*.-de Man, 1916: 5 (list).-Bernard, 1953: 86.-Firth & Pequegnat, 1971: 39 (key), 45.

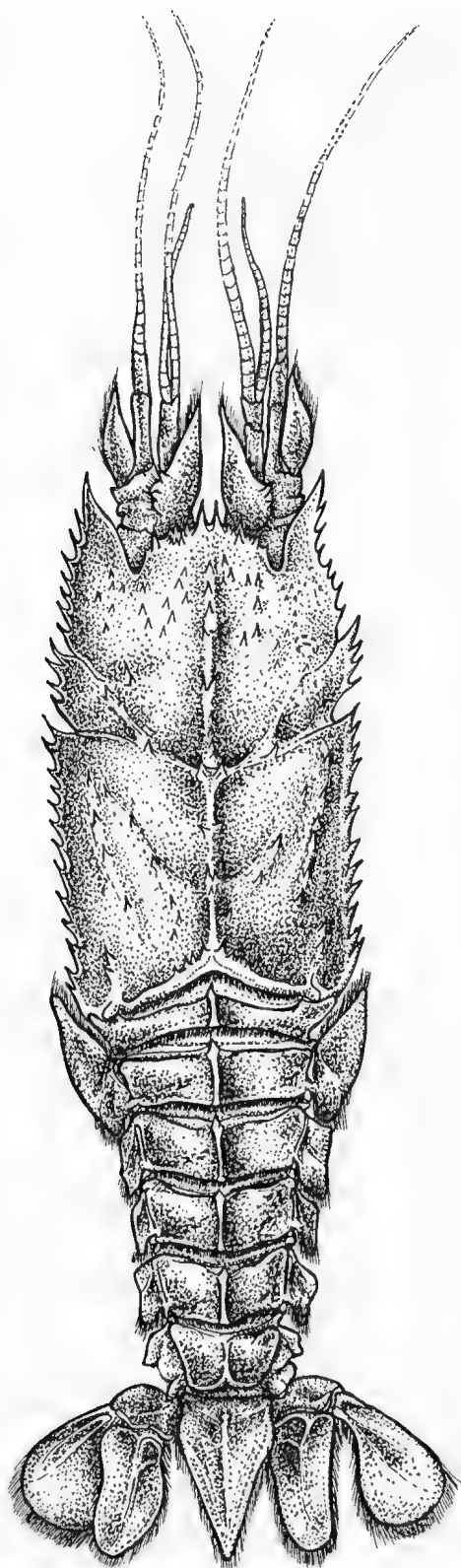


Fig. 2. *Polycheles euthrix* (Bate), male, cl. 39.7 mm, AM P17910, dorsal view.

**Material examined.** Two females, cl. 35 and 36 mm, 1 specimen, cl. approx. 22 mm (very damaged), QM W14280, Coral Sea, 16°55'S 151°34'E, 880 m, P. Davie on RV *Soela*, 6 December 1985; 1 female, cl. 67 mm, 2 males, cl. 55 and 45 mm, QM W14321, 17°01'S 151°20'E, 800 m, P. Davie on RV *Soela*, 6 December 1985; 1 female, cl. 88 mm, QM W14816, 17°02'S 151°03'E, 700 m, P. Davie on RV *Soela*, 6 December 1985; 2 females, cl. 61 and 65 mm, 1 male, cl. 49 mm, QM W14300, 17°38'S 149°23'E to 17°34'S 149°23'E, 600 m, P. Davie on RV *Soela*, 3 December 1985; 1 male, cl. 21.7 mm, QM W14293, 17°30'S 149°00'E to 17°27'S 149°01'E, 900-908 m, P. Davie on RV *Soela*, 2 December 1985; 1 male, cl. 40 mm, QM W11464, 23°37'S 153°16'E, 590 m, MV *Southern Intruder*, 9 August 1983; 1 ovigerous female, cl. 71.4 mm, QM W20795, 27°13.52'S 153°53.46'E, 620 m, R. Morton on MV *Iron Summer*, 31 March 1983; 1 female, cl. 71.3 mm, QM W14336, 27°19.91'S 153°34.47'E, 600 m, MV *Iron Summer*, 10 May 1983; 1 ovigerous female, cl. 62.5 mm, QM W14286, 27°53.90'S 153°00.33'E, 560 m, R. Morton on MV *Iron Summer*, 30 March 1983; 1 female, cl. 55.8 mm, QM W14368, 27°55'S 154°01'E, 555 m, MV *Iron Summer*, 30 November 1982; 1 female, cl. 59.5 mm, QM W14273, 27°56'S 153°54'E, 590 m, S. Hyland on MV *Iron Summer*, 30 November 1982; 2 males, cl. 44.2 and 54 mm, QM W14363, 595 m, MV *Southern Intruder*, 25 April 1984; 1 female, cl. 55.5 mm, AM P44755, north-east of Point Danger, 27°55'S 154°03'E to 27°57'S 154°03'E, trawl, 549 m, 6 November 1978, FRV *Kapala*, stn K78-23-09; 3 females, cl. 30, 54.5 and 55 mm, and 1 ovigerous female, cl. 63 mm, AM P44752, east of Point Danger, 27°55'S 154°03'E to 27°57'S 154°03'E, trawl, 549 m, 6 November 1978, FRV *Kapala*, stn K78-23-09; 1 female, cl. 73 mm, AM P44750, 1 female, cl. 64.5 mm and 1 ovigerous female, cl. 63.5 mm, AM P44751, north-east of Point Danger, 28°02'S 153°59'E to 27°59'S 153°59'E, trawl, 549 m, 2 June 1978, FRV *Kapala*, stn K78-09-05; 3 females, cl. 46, 51 and 69.5 mm, 1 male, cl. 61.5 mm, AM P44754, north-east of Point Danger, 28°03'S 154°04'E to 28°01'S 154°04'E, trawl, 732 m, 6 November 1978, FRV *Kapala*, stn K78-23-08; 1 male, cl. 41 mm, AM P44753, east of Point Danger, 28°12'S 153°53'E to 28°09'S 153°53'E, trawl, 229 m, 2 November 1978, FRV *Kapala*, stn K78-23-05; 1 female, cl. 55.5 mm, 1 male, cl. 49 mm, AM P44756, east of Crowdy Head, 31°56'S 153°08'E to 31°52'S 153°16'E, trawl, 925 m, 9 December 1987, FRV *Kapala*, stn K87-24-05; 1 ovigerous female, cl. 52 mm, AM P39742, east of Hawkes Nest, 32°41'S 152°50'E, beam trawl, 713-796 m, 14 June 1989, FRV *Kapala*, stn K89-11-03; 1 ovigerous female, cl. 51 mm, AM P26754, 4 females (3 ovigerous), cl. 44.5, 47, 48 and 48.5 mm, AM P26755, 1 male, cl. 31 mm, AM P26753, east of Newcastle, 33°11'S 152°24'E to 33°09'S 152°25'E, demersal trawl, 732 m, 7 December 1977, FRV *Kapala*, stn K77-23-10; 1 male, cl. 39.7 mm, AM P17910, south-east of Port Stephens, 32°46'S

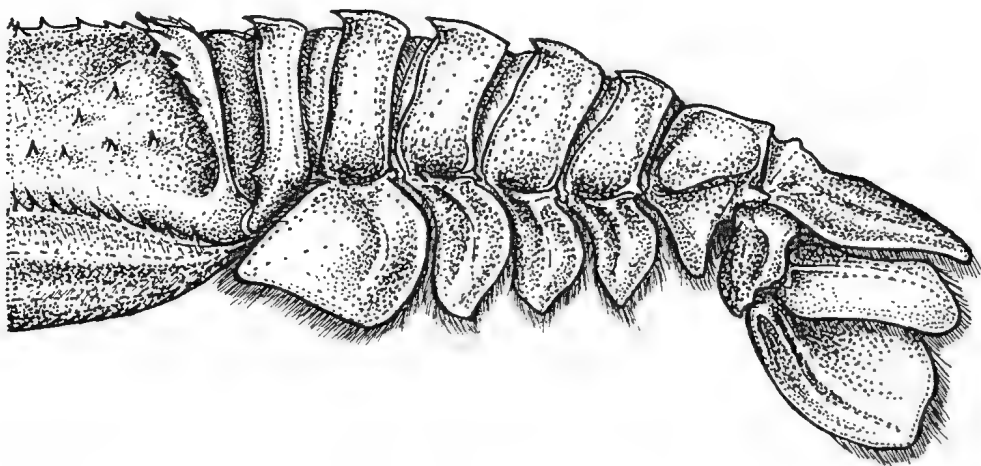


Fig. 3. *Polychaetes euthrix* (Bate), male, cl. 39.7 mm, AM P17910, lateral view of abdomen.

152°46'E to 32°51'S 152°42'E, prawn trawl, sandy mud, 585–594 m, 7 May 1971, FRV *Kapala*, stn K71-09-01; 1 female, cl. 46.5 mm, AM P44757, east of Budgewoi, 33°11'S 152°25'E, beam trawl, 722–768 m, 12 April 1989, FRV *Kapala*, stn K89-06-05; 1 male, cl. 36.5 mm, AM P39743, east of Broken Bay, 33°34'S 152°05'E to 33°38'S 152°01'E, beam trawl, 814–832 m, 25 September 1984, FRV *Kapala*, stn K84-16-05.

**Remarks.** There are two rostral spines and, immediately below, a single small conical tooth projecting from the frontal wall of the carapace. The frontal border of the carapace is convex with 3 or 4 spines and several spinules on either side of the rostral spines. The 39.7 mm male (AM P17910) has 6 or 7 irregularly spaced spines on the frontal border. The orbital notch is subtriangular, the inner and outer borders confluent with the frontal margin, and a small sharp spine overhangs the inner border anteriorly.

The spinal formula of the lateral edges of the carapace is 7–9:3–5:13–16. In nearly all specimens there is some variation between the left and right margins. The spines of the mid-dorsal carina of the carapace (excluding rostral spines) vary from three single followed by two paired spines (1,1,1,2,2) to 1,1,1,2,1 to 1,1,2,2 to 1,1,2,1 before the cervical groove and two paired spines behind it. The posterior border of the carapace has several antrorse spines (one large and several smaller) on each side of the mid-dorsal carina.

The mid-gastric and branchial regions of the carapace bear scattered spines, spinules and granules which are not evident in Bate's figure. Sund (1920) remarked that in the *Challenger* material there was only one spine on the gastric region and none on the branchial regions. Whereas the *Challenger* specimens had only a single spine on the antero-external angle of the basal segment of the antennular peduncle, the present specimens have a small spinule as well as a spine. In one specimen (40 mm male, QM W11464) the spinule is bifid.

**Distribution.** Western Pacific Ocean: eastern Australia, Kermadec Islands, Fiji; 229–1152 m.

### *Polychaetes granulatus* Faxon

Figs 4,5

*Polychaetes granulatus* Faxon, 1893: 197.–Faxon, 1895: 123, pl. 32 fig. 1, pl. 33 figs 2,2a.–Rathbun, 1906: 899, fig. 54.–Selbie, 1914: 23, pl. 3.–de Man, 1916: 5 (list).–Bouvier, 1917: 45, pl. 2 figs 7–14.–Barnard, 1950: 569.–Bernard, 1953: 86.–Zariquiey, 1968: 210.–Firth & Pequegnat, 1971: 40 (key), 47.–Wenner, 1979: 443.–Kensley, 1981: 29.  
*Pentacheles Beaumontii* Alcock, 1894a: 236.–Alcock, 1901: 175.

*Pentacheles beaumontii*.–Alcock, 1894b: pl. 8 fig. 3.  
? *Polychaetes granulatus*.–Balss, 1925: 200.

**Material examined.** Two females, cl. 24.5 and 32.5 mm, AM P44910, Lord Howe Rise, western Tasman Sea, 28°05.76'S 163°06.04'E, beam trawl, coarse ooze and pumice, 1051 m, J.K. Lowry & party on RV *Franklin*, 5 May 1989, stn FR0589-25; 2 males, cl. 17.5 and 19 mm, AM P44909, Lord Howe Rise, western Tasman Sea, 28°44.08'S 161°54.59'E, beam trawl, pale grey ooze, 1325 m, J.K. Lowry & party on RV *Franklin*, 4 May 1989, stn FR0589-22; 4 females, cl. 23.5, 25.5, 30 and 39 mm, 2 ovigerous females, cl. 53 and 59.5 mm, 3 males, cl. 30, 32.5 and 39 mm, AM P44910, east of Diamond Head, 31°46'S 153°18'E to 31°46'S 153°19'E, 1005–1240 m, 21 June 1988, FRV *Kapala*, stn K88-12-03; 1 ovigerous female, cl. 50.5 mm, AM P44904, east of Crowdy Head, 31°56'S 153°08'E to 31°52'S 153°16'E, 485–925 m, 9 December 1987, FRV *Kapala*, stn K87-24-05; 2 ovigerous females, cl. 46.5 and 45.5 mm, 2 males, cl. 31.5 and 42 mm, AM P39721, east of Black Head, 32°01'S 153°10'E, 915–997 m, 15 June 1989, FRV *Kapala*, stn K89-12-05; 5 males, cl. 25, 36.5, 37.5, 45.5 and 46.5 mm, AM P39726, east of Black Head, 32°04'S 153°10'E, 1034–1079 m, 15 June 1989, FRV *Kapala*, stn K89-12-04; 1 ovigerous female, cl. 55.5 mm, AM P44907, east of Crowdy Head, 32°05'S 153°08'E to 32°02'S



Fig. 4. *Polycheltes granulatus* Faxon, male, cl. 32 mm, AM P25047, dorsal view.

153°10'E, 1025 m, 21 June 1988, FRV *Kapala*, stn K88-12-02; 2 females, cl. 52.5 and 62.5 mm, 1 male, cl. 49.5 mm, AM P44905, east of Cape Hawke, 32°06'S 153°08'E to 32°02'S 153°09'E, 1025–1080 m, 4 May 1988, FRV *Kapala*, stn K88-08-04; 3 females, cl. 41.5, 42.5 and 49.5 mm, AM P39724, east of Cape Hawke, 32°06'S 153°08'E to 32°02'S 153°09'E, 942–978 m, 2 November 1983, FRV *Kapala*, stn K83-15-02; 1 female, cl. 51.2 mm, 1 male, cl. 44.5 mm, AM P39719, east of Cape Hawke, 32°08'S 153°09'E to 32°04'S 153°10'E, 1066–1052 m, 18 July 1984, FRV *Kapala*, stn K84-10-04; 1 female, cl. 50.5 mm, 1 male, cl. 41.5 mm, AM P44906, south-east of Crowdy Head, 32°09'S 153°09'E to 32°05'S 153°09'E, 1066–1100 m, 21 June 1988, FRV *Kapala*, stn K88-12-01; 1 male, cl. 41.5 mm, AM P44901, east of Port Stephens, 32°43'S 152°51'E to 32°35'S 152°51'E, 914 m, 18 October 1983, FRV *Kapala*, stn K83-13-03; 1 female, cl. 49 mm, 1 male, cl. 39 mm, AM P39723, north-east of Newcastle, 32°50'S 152°48'E to 32°48'S 152°48'E, 945–990 m, 16 August 1988, FRV *Kapala*, stn K88-16-03; 3 males, cl. 31.5, 37 and 45 mm, AM P39720, north-east of Newcastle, 32°50'S 152°50'E, 1066–1052 m, 8 June 1989, FRV *Kapala*, stn K89-11-02; 1 female, cl. 40 mm, 3 males, cl. 24, 31.5 and 40.5 mm, AM P39722, north-east of Newcastle, 32°50'S 152°50'E, 1079–1097 m, 8 June 1989, FRV *Kapala*, stn K89-11-01; 1 ovigerous female, cl. 44.5 mm, AM P44902, east of Newcastle, 32°57'S 152°44'E to 32°54'S 152°46'E, 540–565 m, 19 October 1983, FRV *Kapala*, stn K83-13-04; 2 females, cl. 46 and 48 mm, 1 ovigerous female, cl. 51.5 mm, AM P39731, east of Newcastle, 32°59'S 152°42'E to 32°54'S 152°44'E, 988–960 m, 18 October 1983, FRV *Kapala*, stn K83-13-02; 1 ovigerous female, cl. 50.5 mm, 4 males, cl. 28, 38.5, 41.5 and 45.5 mm, AM P39725, east of Newcastle, 33°02'S 152°38'E, 896–960 m, 16 May 1989, FRV *Kapala*, stn K89-09-01; 4 females, cl. 23.5, 30, 46.5 and 47 mm, 1 ovigerous female, cl. 49 mm, 2 males, cl. 22 and 32.5 mm, 2 juveniles, cl. 17.5 and 18.5 mm, AM P44896, north-east of Broken Bay, 33°27'S 152°09'E to 33°25'S 152°11'E, 882–914 m, 8 December 1977, FRV *Kapala*, stn K77-23-13; 1 female, cl. 31 mm, AM P39729, north-east of Broken Bay, 33°28'S 152°12'E to 33°33'S 152°10'E, 1080–1135 m, 31 August 1988, FRV *Kapala*, stn K88-17-04; 1 female, cl. 52 mm, 1 male, cl. 43.5 mm, AM P44908, north-east of Broken Bay, 33°30'S 152°10'E, November 1992; 1 female, cl. 22 mm, 1 male, cl. 19 mm, AM P21062, east of Broken Bay, 33°32'S 152°04'E to 33°38'S 152°00'E, 822 m, 19 August 1975, FRV *Kapala*, stn K75-05-05; 1 male, cl. 24.5 mm, AM P39730, east of Broken Bay, 33°32'S 152°07'E, 732–795 m, 17 May 1989, FRV *Kapala*, stn K89-09-06; 2 females, cl. 30.5 and 32 mm, 1 ovigerous female, cl. 43.5 mm, 1 male, 41 mm, 1 juvenile, 23 mm, AM P26787, east of Broken Bay, 33°33'S 152°03'E, 905–914 m, 12 December 1977, FRV *Kapala*, no station number; 2 males, cl. 18.5 and 26 mm, 2 damaged specimens, cl. 18 and 19 mm, AM P38724, east of Broken Bay, 33°33'S 152°09'E, 1022–1051 m, 19 December 1985, FRV *Kapala*, stn K85-21-04; 1 ovigerous female, cl. 47 mm, AM P26811, east of Broken Bay, 33°35'S 152°00'E to 33°33'S 152°02'E, 823 m, 8 December 1977, FRV *Kapala*, stn K77-23-12; 1 male, cl. 32 mm, AM P25047, 1 female, cl. 19 mm, AM P25048, east of Broken Bay, 33°35'S 152°01'E to 33°32'S 152°03'E, 825 m, 20 December 1976, FRV *Kapala*, stn K76-24-03; 1 female, cl. 52.5 mm, AM P44898, east of Broken Bay, 33°36'S 152°06'E to 33°34'S 152°08'E, 914 m, 4 December 1979, FRV *Kapala*, stn K79-20-06; 1 female, cl. 24 mm, 1 juvenile, cl. 18 mm, AM P44899, south-east of Broken Bay, 33°39'S 152°06'E to 33°37'S 152°07'E, 990 m, 6 December 1979, FRV *Kapala*, stn K79-20-15; 1 male, cl. 18.5 mm, AM P26778,



Fig. 5. *Polycheles granulatus* Faxon, male, cl. 32 mm, AM P25047, carapace.

south-east of Broken Bay, 33°40'S 151°56'E to 33°37'S 151°56'E, 732 m, 6 December 1977, FRV *Kapala*, stn K77-23-06; 2 females, cl. 24.5 and 30 mm, 1 male, cl. 23 mm, AM P39727, south-east of Broken Bay, 33°41'S 152°01'E, 805–869 m, 9 May 1989, FRV *Kapala*, stn K89-08-01; 1 female, cl. 41.5 mm, AM P38727, north-east of Long Reef Point, 33°43'S 152°03'E to 33°40'S 152°05'E, 1042–1070 m, 27 September 1984, FRV *Kapala*, stn K84-16-14; 1 female, cl. 23 mm, AM P20639, east of Long Reef Point, 33°44'S 151°55'E to 33°40'S 151°58'E, 720 m, 9 November 1972, FRV *Kapala*, stn K72-07-04; 1 male, cl. 32.5 mm, AM P44903, east of Long Reef Point, 33°44'S 151°57'E, 820–889 m, 11 February 1986, FRV *Kapala*, stn K86-01-07; 1 ovigerous female, cl. 59 mm, AM P39728, east of Long Reef Point, 33°45'S 152°00'E to 33°41'S 152°03'E, 969–1006 m, 1 November 1984, FRV *Kapala*, stn K84-20-03; 2 males, cl. 28.5 and 30 mm, AM P44897, east of Shoalhaven Bight, 34°55'S 151°13'E to 34°53'S 151°14'E, 823 m, 12 December 1978, FRV *Kapala*, stn K78-27-05; 1 female, cl. 31.5 mm, AM P44900, south-east of Point Hicks, 38°19'S 149°47'E to 38°17'S 149°49'E, 997–1017 m, 27 September 1983, FRV *Kapala*, stn K83-12-04; 1 female, 30.5 mm, AM P45098, off St Patricks Head, Tasmania, approx. 41°20'S 148°50'E, demersal trawl, 1100 m, K. Graham on FRV *Soela*, 12 July 1987, stn SO5/87/15.

**Remarks.** These specimens agree more closely with Alcock's description and figure (Alcock, 1894b, pl. 8, fig. 3) of *Pentacheles beaumontii* than with Faxon's (1895, pl. 33, figs 2, 2a) description and figure of *Polycheles granulatus* except that the scaphocerite is normally developed, as in *P. granulatus*. *Polycheles granulatus* appears very fragile and delicate. The carapace is somewhat ovate in shape with a finely granulate surface and lacks large spines except anteriorly on the medial carina and the lateral edges.

There are two strong rostral spines and a strong spine on both internal and external angles of the orbital notch. The orbital notch is relatively narrow and deep and the ocular peduncle has a spine on the anterior border.

The spinal formula of the lateral edge of the carapace is 7–9:3–4:13–17. The arrangement of spines along the mid-dorsal carina (excluding rostral spines) of the carapace varies from one to three single spines to two or three more or less paired spines, followed by smaller spinules or granules anterior to the cervical groove and paired low granules behind it. Only the superior branchial carina is obvious and is composed of minute spinulose granules. The posterior edge of the carapace is smooth.

**Colour.** (Based on AM P25047). Entire carapace, abdominal segments and telson light rose pink, spines tipped with white. Antennular and antennal flagella and peduncles, pereopods, pleopods, endopods and exopods of uropods a darker pink to red.

**Distribution.** Atlantic Ocean: south-west coast of Ireland, Spain, Madeira and Canary Islands, Azores, Nova Scotia, mid-Atlantic Bight, south-western Africa; Indian Ocean: Sri Lanka; Pacific Ocean: south-eastern Australia, western Tasman Sea, Hawaiian Islands; 347–2505 m.

### *Polycheles typhlops typhlops* Heller

Figs 6–8

*Polycheles typhlops* Heller, 1862: 392, pl. 1 figs 1–6. –Kemp & Sewell, 1912: 23. –de Man, 1916: 2, 6, 24. –Bouvier, 1917: 35, pl. 2 figs 1–6. –Balss, 1925: 201, pl. 19 figs 12–14. –Bernard, 1953: 3, 86. –Lewinsohn & Holthuis, 1964: 54. –Zariquiey, 1968: 209, fig. 86b. –George, 1983: 16, 19 (key), 20. –Baba *et al.*, 1986: 156, 283, fig. 107. –Chan & Yu, 1989b: 166, pl. 1A,B.

*Pentacheles Hextii* Alcock, 1894a: 237. –Alcock, 1901: 172. –Alcock & Anderson, 1895: pl. 10 figs 2, 2a–c.

*Polycheles typhlops typhlops*. –Firth & Pequegnat, 1971: 39 (key), 51, fig. 7. –Wadley & Evans, 1991: 27, unnumbered figs.

**Material examined.** One male, cl. 49 mm, QM W11220, east of Murray Isles, Torres Strait, 9°50'S 144°11'E to 9°51'S 144°09'E, 460 m, Queensland Fisheries Service on *Gwendoline May*, 21 May 1983; 1 male, cl. 43.5 mm, AM P44911, south-east of Cape Byron, 28°37'S 153°50'E, 502 m, 19 August 1978, FRV *Kapala*, stn K78-17-21; 1 male,



Fig. 6. *Polychelotes typhlops typhlops* Heller, male, cl. 34.4 mm, AM P21799, dorsal view.

cl. 34.5 mm, AM P21799, north-east of Wooli, 29°52'S 153°43'E to 29°46'S 153°45'E, 503 m, 10 October 1975, FRV *Kapala*, stn K75-09-03; 1 male, cl. 39.5 mm, AM P20638, north-east of Broken Bay, 33°30'S 152°05'E to 33°26'S 152°08'E, 549 m, 5 October 1972, FRV *Kapala*, stn K75-02-08; 1 female, cl. 39 mm, AM P39741, east of Broken Bay, 33°34'S 151°57'E, 549–568 m, 10 September 1984, FRV *Kapala*, stn K84-15-02; 1 male, cl. 36 mm, AM P39740, east of Wollongong, 34°19'S 151°27'E to 34°24'S 151°24'E, 512 m, 19 July 1979, FRV *Kapala*, stn K79-08-12; 1 male, cl. 30.5 mm, AM P44912, east of Shoalhaven Bight, 34°42'S 151°15'E to 34°38'S 151°16'E, 613–640 m,

10 October 1984, FRV *Kapala*, stn K84-18-04; 1 male, cl. 26.8 mm, AM P20637, off New South Wales, 1971, FRV *Kapala*.

**Remarks.** *Polychelotes typhlops* has been well described and figured by many authors. These specimens have the characteristic orbital notch described by Firth & Pequegnat (1971). The orbital peduncle has a sharp spine on the anterior edge. The carapace is long and narrow, its surface covered by minute spinules. Immediately below a single rostral spine, a conical tooth projects from the frontal wall of the carapace. The spinal formula of the lateral edges of the carapace is 7–9:5–6:24–26. The mid-dorsal carina is a line of irregularly spaced single, or posteriorly, paired spines anterior to the cervical groove and paired granules or occasionally spines behind the cervical groove. The posterior edge of the carapace is armed with several antrorse spines, two to three on each side of the mid-dorsal carina. The gastro-orbital carina is faint and comprises four antrorse spines or spinules; the superior branchial carina is marked by a line of 12–15 similar spines sometimes becoming smaller posteriorly. Other spines or spinules are located along the posterior branch of the cervical groove and on the branchio-cardiac carina.

Two subspecies are presently recognised: *Polychelotes typhlops typhlops* Heller and *P. typhlops perarmatus* Holthuis (1952a). Firth & Pequegnat (1971) reported two intergrading forms which they termed "Form A" and "Form B" from the Gulf of Mexico and the Caribbean Sea. The east Australian males would be closer to Firth & Pequegnat's "Form B". They agree in having two to four spines on each side of the posterior border of the carapace, the second pleuron anteriorly obtuse (or right angled), tubercles on the edges of the pleura, 14–27 blunt tubercles on the edges of the terga, and strong spines on the cheliped. They differ from "Form B" in having only a partial third carina on the exopodites of the uropods and some spinules or small spines on the carina of the cervical groove. However, the two most important characteristics of the subspecies *P. typhlops perarmatus* are the rounded shape of the second pleuron and the great number of sharp spines on the edges of the terga. The east Australian specimens do not have these features and must be considered as *P. typhlops typhlops*.

**Colour.** (Based on AM P21799). Medial gastric and frontal region, scaphocerite and antennular peduncles, anterolateral edges and posterior border of carapace, cervical groove, mid-dorsal carina of carapace, carinae and granulate edges of abdominal terga bright orange. Remaining portions of carapace, abdominal terga and pleura white. Cheliped with proximal portion of merus white, distal third of merus and carpus orange. Upper surface of propodus and fingers orange, shading to pinkish white on underside and distal portions. All other pereopods white.





Fig. 7. *Polycheles typhlops typhlops* Heller, male, cl. 34.4 mm, AM P21799, carapace.

**Distribution.** Atlantic Ocean; Mediterranean Sea; Caribbean Sea; Gulf of Mexico; Indian Ocean; Western Pacific Ocean, western and eastern Australia; 183–2195 m.

#### *Stereomastis* Bate, 1888

The genus contains twelve species, of which nine are known from the Indo-West Pacific region. Two species have been previously recorded from Australian waters: *Stereomastis phosphorus* (Alcock, 1894) from north-western Australia (George, 1983; Wadley & Evans, 1991) and *S. nana* (Smith, 1884), also from north-western Australia (George, 1983).

#### *Stereomastis andamanensis* (Alcock)

- Pentacheles andamanensis* Alcock, 1894a: 233 (key), 239.–Alcock & Anderson, 1896: pl. 10 fig. 3.  
*Polycheles andamanensis*.—Alcock, 1901: 167 (key), 169.–Bouvier, 1917: 35 (list).—Ramadan, 1938: 124.  
*Stereomastis andamanensis*.—de Man, 1916: 4 (list), 8 (key), 16, pl. 1 fig. 2.—Bernard, 1953: 87.—Takeda & Hanamura, 1994: 31.

**Material examined.** One male, cl. 34.5 mm, AM P40367, Coral Sea, 10°34.28'S 144°13.33'E, beam trawl, 815–825 m, P. Hutchings & party on RV *Franklin*, 20–21 August 1988, stn FR0688-4; 1 male, cl. 22 mm, AM P40368, Lord Howe Rise, western Tasman Sea, 27°39.8'S 161°46.3'E, beam trawl, 1423 m, J.K. Lowry & party on RV *Franklin*, 6 May 1989, stn FR0589-31; 1 ovigerous female, cl. 43.5 mm, AM P40370 and 1 female, cl. 37 mm, AM P40371, Lord Howe Rise, western Tasman Sea, 27°59.3'S 162°48.6'E, beam trawl, coarse ooze with pumice, 1250 m, J.K. Lowry & party on RV *Franklin*, 5 May 1989, stn FR0589-27; 2 ovigerous females, cl. 38.5 and 40.5 mm, AM P40369, north-east of Tuncurry, 32°04'S 153°10'E, beam trawl, 1034–1079 m, 15 June 1989, FRV *Kapala*, stn K89-12-04; 1 ovigerous female, cl. 41.5 mm, AM P40373, north-east of Tuncurry, 32°06'S 153°08'E to 32°02'S 153°09'E, beam trawl, 1025–1080 m, 4 May 1988, FRV *Kapala*, stn K88-08-04; 1 ovigerous female, cl. 42 mm, AM P40374, north-east of Port Hunter, 32°50'S 152°50'E, 1079–1097 m, 8 June 1989, FRV *Kapala*, stn K89-11-01; 1 ovigerous female, cl. 39 mm, AM P40375, east of Port Hunter, 32°55'S 152°45'E, 1043–1061 m, 11 April 1989, FRV *Kapala*, stn K89-06-02; 1 female, cl. 44.5 mm, AM P40376, south-east of Cape Hawke, 33°26'S 152°14'E, 1134–1189 m, 10 May 1989, FRV *Kapala*, stn K89-08-02; 1 ovigerous female, cl. 44.5 mm, AM P40377, east of Broken Bay, 33°28'S 152°12'E to 33°33'S 152°10'E, 1080–1135 m, 31 August 1988, FRV *Kapala*, stn K88-17-04; 1 female, cl. 30.5 mm, AM P38725, off Shoalhaven Bight, 34°55'S 151°15'E to 34°51'S 151°17'E, trawl, 1170–1207 m, 2 August 1984, FRV *Kapala*, stn K84-11-09.

**Remarks.** The rostrum is bifid, the orbital notches broad V-shaped, with a single sharp spine at the internal orbital angle. The ocular peduncle has a short, laterally-directed spine on the centre of its anterior margin. There are two spines on the basal antennular segment, as in the type specimen. The posterior spine is about half the length of the anterior spine and usually hidden by fine setae. De Man (1916) found only a single spine on each side in the *Siboga* material, except in one small female.

The mid-dorsal carina of the carapace, behind the rostral spines, has spinal formula 1,1,2,1 before the cervical groove and 2,2,2 behind it. One specimen, a 44.5 mm ovigerous female (AM P40376), has a mid-dorsal spinal formula of 1,1,2,1,1,1. However, two of the three posterior spines are irregularly spaced and appear to be abnormal.

The spinal formula of the lateral edge of the carapace is 5–6:3–4:6–8. All specimens except one have five spines along the slightly sinuous sublateral ridge of the branchial region, as in the type specimen. De Man (1916) recorded seven or eight sublateral spines in most of the *Siboga* material.

The median carina of abdominal segments 1 to 5 is produced into a spine. The spine on segment 5 is slightly smaller than that on segment 4. The spine on segment 4 is smoothly curved, as in Alcock & Anderson's (1896) plate 10 figure 3a, rather than de Man's (1916) plate 1 figure 2a. The double carina of segment 6 is strongly nodular and united posteriorly by a taller nodule. There is a low, double-peaked nodule on the telson. The merus of the cheliped has one small spine about midway



Fig. 8. *Polycheles typhlops typhlops* Heller, male, cl. 34.4 mm, AM P21799, lateral view.

along the upper margin. Alcock (1894a) recorded two spines and de Man (1916) mentioned two to three. The lower margin has no spines but is finely spinulose on its distal half.

One specimen, a 34.5 mm male (AM P40367) differs from the other material in several small points. The left antennular basal segment has only one spine; the right has two spines, but the posterior one is larger than the anterior one; the spine on the ophthalmic peduncle is very short and blunt; there are seven spines on the sublateral ridge of the branchial region, which is not sinuous; there are no spinules on the posterior margin of the carapace. This specimen thus agrees with de Man's description of the *Siboga* material in aspects which differ slightly from the type specimen. It is interesting to note that this specimen is from the Coral Sea whereas the rest of the present material is from much further south, in the Tasman Sea.

Six of the specimens (AM P40371, P40373 to P40376) have a slender spine, arising between the bases of the two rostral spines, at the extreme anterior edge of the carapace. This spine is almost as long as, and projects at much the same angle as, the rostral spines. The other six specimens do not have such a spine and there are no intermediate forms. This subrostral spine is not the "small, obtuse tubercle" mentioned by de Man (1916: 19). Such a tubercle also occurs in all the present material. It is small and arises low down on the frontal wall of the carapace, unlike the prominent conical tooth of *S. phosphorus*. The subrostral spine of the present material seems to be the same as that described by Smith (1884: 15) in *S. nana*. *Stereomastis nana* is similar to *S. andamanensis* but can be distinguished from it by the absence of any spine on the internal orbital angle in *S. nana*. Also, in *S. nana* the large antrorse spine of the fifth abdominal segment is at least as large as the fourth, whereas in *S. andamanensis* the fifth spine is smaller than the fourth.

The six specimens with extra subrostral spine and three of those without (AM P38725, P40368 and P40370) have slender spinules, rather than granules, on the posterior border of the carapace. De Man (1916: 18)

suggested that spinules occur in smaller specimens and granules in the larger specimens. However, in our material the specimens with spinules are ovigerous females and an adult male.

**Distribution.** Indo-West Pacific Ocean: Arabian Sea, northern Indian Ocean, Indonesia, Coral Sea, western Tasman Sea; 724–2000 m.

#### *Stereomastis helleri* (Bate)

*Polycheles Helleri* Bate, 1878: 277 (in part).

*Polycheles helleri*.—Bate, 1888: 138 (in part), pl. 14 fig. 2 (not female from station 170, pl. 15 fig. 1, = *S. kermadecensis* Sund, 1920).—Sund, 1920: 224.

**Material examined.** One male, cl. 19 mm, AM P40360, Coral Sea, 11°33.02'S 145°19.34'E, 1611–1584 m, P. Hutchings & party on RV *Franklin*, 22 August 1988, stn FR0688-11.

**Remarks.** This single specimen agrees well with Bate's (1888) description and figures of the small male type specimen. The rostrum is bifid, the orbital notches deep U-shaped; there is no spine on either side of the inner or outer orbital angle. The spine on the ophthalmic peduncle is strong and directed slightly laterally. There are two spines on the basal antennular segment. The mid-dorsal carina, behind the rostral spines, has spinal formula 1,1,2,1 before the cervical groove and 2,2,2 behind it. The posterior margin of the carapace has a series of low but distinct, regularly spaced granules. The spinal formula of the right lateral margin is 6:3:2–3, that is, on the margin posterior to the cervical groove the anterior and posterior teeth are distinct, but between these teeth there are indistinct granules, just as described by Bate. The left margin is damaged. The sublateral carinae of the branchial region are similarly armed, having five to six distinct spines interspersed, particularly in the middle, with indistinct granules. The most posterior spine is strongest, as noted by Bate.



Abdominal segments 1 to 5 have the median carina produced into an anteriorly projecting spine, that on segment 5 being the largest. The double carina of segment 6 is low, irregular, united posteriorly. There is a single low but long nodule on the anterior portion of the telson. The anterior margin of abdominal pleuron 2 is broadly rounded proximally, without any spine, but obliquely angled on its lower half. There are a few small blunt spinules on the posteroventral margin of pleura 3 to 6.

Both chelipeds are missing from the specimen.

This species is very similar to *S. nana* (Smith, 1884) from the Atlantic and eastern Pacific (Faxon, 1895), especially in the absence of a spine on the inner orbital angle and in the distribution of spines on the lateral margin of the carapace. The material from north-western Australia reported by George (1983) as *S. nana* is possibly *S. helleri*.

**Distribution.** South-west Pacific Ocean: north of Papua New Guinea, Coral Sea; 1611–1957 m.

*Stereomastis phosphorus* (Alcock)

Figs 9–11

*Pentacheles phosphorus* Alcock, 1894a: 240.–Alcock, 1894b: pl. 8 fig. 2.

*Polychaetes phosphorus*.–Alcock, 1901: 167 (key), 168.–Rathbun, 1906: 898.–Kemp & Sewell, 1912: 24.–Bouvier, 1917: 35 (list).

*Stereomastis phosphorus*.–de Man, 1916: 4 (list), 15.–Bernard, 1953: 87.–Firth & Pequegnat, 1971: 64 (key), 68.

*Stereomastis* cf. *phosphorus*.–Wadley & Evans, 1991: 28, unnumbered figs.

**Material examined.** One juvenile, cl. 21 mm, AM P44919, Torres Strait; 10°34.28'S 144°13.33'E, beam trawl, 815–825 m, P. Hutchings & party on RV *Franklin*, 21 August 1988, stn FR0688-4; 1 male, cl. 30.5 mm, AM P44920, Torres Strait, 10°37.17'S 144°21.99'E, beam trawl, 990–1053 m, P. Hutchings & party on RV *Franklin*, 21 August 1988, stn FR0688-54; 1 female, cl. 61.7 mm, QM W14294, 23°40'S 153°56.9'E, 530 m, G. Smith on MV *Iron Summer*, 22 November 1982; 1 ovigerous female, cl. 50.5 mm, 3 males, cl. 41, 50 and 55.3 mm, QM W14355, south-east Queensland, 26°31'S 153°48'E, 570 m, G. Smith on MV *Iron Summer*, 13 December 1982; 1 ovigerous female, cl. 61.5 mm, QM W14328, 27°12.83'S 153°52.87'E, R. Morton on MV *Iron Summer*, 10 May 1983; 2 ovigerous females, cl. 50 and 70 mm, QM W14313, 27°13.00'S 153°52.53'E, 590 m, R. Morton on MV *Iron Summer*, 9 May 1983; 1 ovigerous female, cl. 50 mm, QM W14282, 27°13.52'S 153°53.46'E, 620 m, R. Morton on MV *Iron Summer*, 31 March 1983; 1 ovigerous female, cl. 70 mm, QM W14262, 27°13.69'S 153°54.93'E, 600 m, R. Morton on MV *Iron Summer*, 31 March 1983; 1 male, cl. 39.5 mm, QM W14381, 27°16'S 153°53'E, 540 m, G. Smith on MV *Iron Summer*, 13 August 1982; 1 male, cl. 51 mm (very damaged), QM W14344, 27°35.04'S 153°57.32'E, 545 m, R. Morton on MV *Iron Summer*, 31 March 1983; 1 ovigerous female, cl. 48 mm, QM W14367, 27°S 153°36'E, 540 m, P. Dutton on MV *Iron Summer*, 29 July 1982; 1 male, cl. 40 mm, QM



Fig. 9. *Stereomastis phosphorus* (Alcock), female, cl. 42.5 mm, AM P20664, dorsal view.

W14323, 27°59'S 154°00.5'E, S. Hyland on MV *Iron Summer*, 4 December 1982; 1 ovigerous female, 61.9 mm, QM W14276, 27°59.37'S 154°00'E, R. Morton on MV *Iron Summer*, 31 March 1983; 1 female, 67.5 mm, QM W14352, 28°01'S 154°01'E, 580 m, S. Hyland on MV *Iron Summer*, 4 December 1982; 4 females, 24, 30.5, 33.5 and 34 mm, 3 ovigerous females, cl. 45.5, 53 and 53.5 mm, 2 males, cl. 26.5 and 48.5 mm, AM P44914, north-east of Point Danger,



Fig. 10. *Stereomastis phosphorus* (Alcock), female, cl. 42.5 mm, AM P20664, carapace.

28°01'S 154°00'E, 548 m, 17 August 1978, FRV *Kapala*, stn K78-17-10; 1 female, cl. 49 mm, 1 male, cl. 42 mm, AM P44915, north-east of Point Danger, 28°03'S 154°04'E to 28°01'S 154°04'E, 732 m, 6 November 1978, FRV *Kapala*, stn K78-23-08; 1 female, cl. 54 mm, 1 ovigerous female, cl. 56 mm, AM P44913, east of Minnie Water, 29°45'S 153°45'E to 29°42'S 153°46'E, 505 m, 19 April 1978, FRV *Kapala*, stn K78-05-06; 1 female, cl. 49.5 mm, AM P39732, north-east of Woolli, 29°50'S 153°43'E to 29°48'S 153°44'E, 503 m, 25 April 1978, FRV *Kapala*, stn K78-06-02; 1 ovigerous female, cl. 70 mm, AM P21687, north-east of Woolli, 29°52'S 153°43'E to 29°46'S 153°45'E, 505 m, 10 October 1975, FRV *Kapala*, stn K75-09-03; 2 males, cl. 28.5 and 36.5 mm, AM P26554, north-east of Woolli, 29°53'S 153°42'E, 485 m, 23 August 1977, FRV *Kapala*, stn K77-13-12; 1 female, cl. 44.5 mm, 3 males, cl. 28.5, 34.5 and 38.5 mm, 2 juveniles, cl. 17 and 25 mm, AM P26804, south-east of Newcastle, 33°08'S 152°27'E to 33°10'S 152°24'E, 594 m, 7 December 1977, FRV *Kapala*, stn K77-23-09; 3 males, cl. 20, 29 and 35.5 mm, AM P26757, south-east of Newcastle, 33°11'S 152°24'E to 33°09'S 152°25'E, 732 m, 7 December 1977, FRV *Kapala*, stn K77-23-10; 1 male, cl. 31 mm, AM P44918, east of Budgewoi, 33°11'S 152°25'E, 722–768 m, 12 April 1989, FRV *Kapala*, stn K89-06-05; 1 female, cl. 30 mm, AM P20661, north-east of Broken Bay, 33°30'S 152°05'E to 33°26'S

152°08'E, 549 m, 5 October 1972, FRV *Kapala*, stn K72-05-08; 2 females, cl. 37.5 and 45 mm, AM P39733, east of Broken Bay, 33°32'S 152°07'E, 732–795 m, 17 May 1989, FRV *Kapala*, stn K89-09-06; 2 females, cl. 29.5 and 42.5 mm, 1 male, cl. 41.4 mm, AM P21065, east of Broken Bay, 33°32'S 152°04'E to 33°38'S 152°00'E, 823 m, 19 August 1975, FRV *Kapala*, stn K75-05-05; 1 female, cl. 31.5 mm, AM P39736, east of Broken Bay, 33°34'S 152°04'E to 33°31'S 152°06'E, 725 m, 4 December 1979, FRV *Kapala*, stn K79-20-04; 1 male, cl. 30 mm, AM P39734, east of Broken Bay, 33°34'S 151°57'E, 549–568 m, 10 September 1984, FRV *Kapala*, stn K84-15-02; 1 female, cl. 41 mm, 1 male, cl. 29.5 mm, AM P20663, between Broken Bay and Port Jackson, approx. 33°40'S 150°59'E, 594 m, 9 October 1972, FRV *Kapala*, stns K72-05-09 to 72-05-11; 1 female, cl. 29 mm, AM P44917, south-east of Broken Bay, 33°39'S 151°58'E, 636–647 m, 25 September 1984, FRV *Kapala*, stn K84-16-03; 2 females, cl. 29 and 41 mm, AM P26775, south-east of Broken Bay, 33°40'S 151°56'E to 33°37'S 151°56'E, 714–732 m, 6 December 1977, FRV *Kapala*, stn K77-23-06; 1 female, cl. 26 mm, 1 male, cl. 34 mm, AM P18985, south-east of Broken Bay, 33°43'S 151°55'E to 33°37'S 152°02'E, 775 m, 19 October 1972, FRV *Kapala*, stn K72-06-04; 2 females, cl. 27 and 43.5 mm, AM P18982, south-east of Broken Bay, 33°44'S 151°55'E to 33°40'S 151°58'E, 720 m, 9 November 1972, FRV *Kapala*, stn K72-07-04; 1 male, cl. 38 mm, AM P39735, east of Long Reef Point, 33°47'S 151°50'E to 33°45'S 151°52'E, 503–567 m, 19 May 1983, FRV *Kapala*, stn K83-01-08; 1 male, cl. 26 mm, AM P20662, east of Port Jackson, 33°50'S 150°50'E to 33°46'S 150°52'E, 594 m, 9 October 1972, FRV *Kapala*, stn K72-05-09; 1 male, cl. 41.5 mm, AM P18984, east of Port Jackson, 33°51'S 151°51'E to 33°45'S 151°55'E, 775 m, 19 October 1972, FRV *Kapala*, stn K72-06-03; 1 male, cl. 41.5 mm, AM P18019, east of Port Hacking, 34°11'S 151°36'E to 34°05'S 151°41'E, 720 m, 23 June 1971, FRV *Kapala*, stn K71-10-01; 1 ovigerous female, cl. 40 mm, AM P39737, east of Shoalhaven Heads, 34°50'S 151°15'E, 914–950 m, 10 October 1984, FRV *Kapala*, stn K84-18-03; 1 female, cl. 42.5 mm, AM P20664, east of Shoalhaven Bight, 34°54'S 151°11'E to 34°59'S 151°09'E, 732–805 m, 4 June 1975, FRV *Kapala*, stn K75-02-08; 1 male, cl. 28.5 mm, AM P44916, east of Shoalhaven Bight, 34°55'S 151°13'E to 34°53'S 151°14'E, 823 m, 12 December 1978, FRV *Kapala*, stn K78-27-05; 1 female, cl. 45.5 mm, 3 males, cl. 40, 43 and 45 mm, AM P39738, east of Beecroft Peninsula, 35°03'S 151°08'E, 695–768 m, 18 April 1989, FRV *Kapala*, stn K89-07-01.

**Remarks.** In most specimens the mid-dorsal carina of the carapace (excluding the rostral spines), has spinal formula of 1,1,2,1 in front of the cervical groove and 2,2,2 behind the groove, characteristic of the species. However, three specimens (AM P21687, P39738 and QM W13313), all large females, have four single spines in front of the cervical groove; they are otherwise good examples of *S. phosphorus*. The gastro-orbital carina is composed of three small spines in an oblique row; there are one or two spines mesially on the gastric region and a spine on the cervical groove at the junction of the two branches.

The cervical groove has a spine approximately midway along the posterior border and the superior branchial carina bears a few spines. The surface of the carapace is generally very pubescent. The east Australian specimens differ from Alcock's original description of *S. phosphorus*



Fig. 11. *Stereomastis phosphorus* (Alcock), female, cl. 42.5 mm, AM P20664, lateral view.

in having two spines on the antero-external angle of the basal antennular segment instead of one, and nine to thirteen spines on the lateral edges of the carapace (behind the cervical groove) instead of six or seven. The spinal formula is thus 5-7:3-4:9-13. De Man's specimen of *S. phosphorus* from the *Siboga* Expedition differed similarly. The east Australian specimens also differ in having a conical tooth, quite large in some specimens, projecting from the frontal wall of the carapace but concealed by dense setae.

**Colour.** (Based on AM P20664 and P21065.) Uniformly rose pink except for some grey patches on branchial regions (extending up to the gastric regions) of the carapace. All pereopods rose pink. Ischium of cheliped rose pink; merus white on proximal half and rose pink distally; carpus, propodus and fingers rose pink, distal portions of fingers shading to white. Joints between merus and carpus, carpus and propodus, proximal portion of merus and tips of the fingers whitish.

**Distribution.** Indo-Pacific Ocean: Arabian Sea, Andaman Sea, Bay of Bengal, Gulf of Mannar, Laccadive Sea, Island of Rotti, western and eastern Australia, Hawaiian Islands; 101-1479 m.

### *Stereomastis sculpta* (Smith)

*Polychaetes sculptus* Smith, 1880a: 346, pl. 7.-Smith, 1880b: 270, figs 1-4.-Alcock, 1901: 168 (key), 170.-Stebbing, 1902: 36.-Hansen, 1908: 41.-Selbie, 1914: 11 (key), 18, pl. 2 figs 1-9.-Bouvier, 1917: 35 (key), 51, pl. 3 fig. 1.-Bouvier, 1925: 438, figs 11,12, pl. 7 fig. 1.-Barnard, 1964: 12.

*Pentacheles sculptus*.-Smith, 1882: 23, pls 3,4.-Smith, 1884: 358.-Smith, 1887: 650.-Alcock & Anderson, 1899: 289. *Stereomastis sculpta*.-de Man, 1916: 7 (key), 8.-Calman, 1925: 18.-Barnard, 1950: 572, fig. 105d.-Kensley, 1968: 293.-Kensley, 1981: 29.-Wenner, 1979: 441. *Pentacheles spinosus* Milne Edwards, 1880: 66.

**Material examined.** One ovigerous female, cl. 41.5 mm, AM P40363, north-east of Cape Hawke, 32°06'S 153°08'E to 32°02'S 153°09'E, 1025-1080 m, 4 May 1988, FRV *Kapala*, stn K88-08-04; 1 female, cl. 25.5 mm, AM P40364, north-east of Cape Hawke, 32°04'S 153°10'E, 1034-1079 m, 15 June 1989, FRV *Kapala*, stn K89-12-04; 2 females, cl. 23 and 49.5 mm, 1 male, cl. 27 mm, AM P40365, east of Broken Bay, 33°27'S 152°09'E to 33°25'S 152°11'E, 882-914 m, 8 December 1977, FRV *Kapala*, stn K77-23-13; 1 ovigerous female, cl. 54 mm, AM P40366, east of Shoalhaven Bight, 34°56'S 151°13'E to 34°53'S 151°14'E, 905-924 m, 11 April 1984, FRV *Kapala*, stn K84-04-09.

**Remarks.** The rostrum is bifid, the orbital notches broad U-shaped, with a single spine on the inner orbital angle. The anterior margin of the ocular peduncle bears only a minute, barely-discernible blunt spine. There are two spines on the basal antennular segment. The mid-dorsal carina of the carapace, behind the rostral spines, has spinal formula 1,2,1 before the cervical groove and 2,2,2 behind it. The posterior margin of the carapace is granular. The spinal formula of the lateral margins of the carapace is 6:3:7-8. There are five spines on the slightly sinuous sublateral ridge of the branchial region; the last spine is larger than the others.

The median carina of abdominal segments 1 to 5 is produced into a spine, that of the fourth segment being the largest. The double carina of segment 6 is low, smooth and united posteriorly. There is a single blunt nodule on the anterior portion of the telson. There is no spine on the anterior midpoint of the second abdominal pleuron.

The number of spinules on the upper margin of the cheliped merus varies. There are three in the 27 mm male, one in the 25.5 mm female, two in the 41.5 mm female and none in the 49.5 mm and 54 mm females. Both chelipeds of the 23 mm female are missing.

Faxon (1895) described a subspecies, *S. sculpta pacifica*, which differed in general shape of the carapace, the presence of a spine on the branchial region level with the second spine of the submarginal carina, a larger spine on the ophthalmic lobe and a slightly different shape to the second abdominal pleuron. In all these

respects, the east Australian material corresponds to the original description of the Atlantic form, rather than to the east Pacific subspecies.

**Distribution.** North and South Atlantic Ocean; Mediterranean Sea; Indo-West Pacific Ocean: Indonesia, eastern Australia; 457–2836 m.

*Stereomastis suhmi* (Bate)

Figs 12–15

*Pentacheles Suhmi* Bate, 1878: 278.

*Stereomastis suhmi*.—Bate, 1888: 154; figs 37,38; pl. 15 figs 3,4.—de Man, 1916: 5 (list).—Sund, 1920: 223.—Calman, 1925: 19, pl. 3 fig. 9.—Barnard, 1950: 574, fig. 105f.—Holthuis, 1952b: 78.—Bernard, 1953: 87.—Firth & Pequegnat, 1971: 63 (key), 72.

*Polycheles suhmi*.—Bouvier, 1917: 35 (list).

**Material examined.** One female, cl. 25 mm, AM P20640, south-east of Port Stephens, 32°46'S 152°46'E to 32°51'S 152°42'E, 585–576 m, 7 May 1971, FRV *Kapala*, stn K71-09-01; 1 male, cl. 21 mm, AM P26805, south-east of Port Hunter, 33°08'S 152°27'E to 33°10'S 152°24'E, 594 m, 7 December 1977, FRV *Kapala*, stn K77-23-09; 1 male, cl. 27.5 mm, 1 female, cl. 30.5 mm, AM P26756, south-east of Port Hunter, 33°11'S 152°24'E to 33°09'S 152°25'E, 732 m, 7 December 1977, FRV *Kapala*, stn K77-23-10; 1 female, cl. 28 mm, AM P20641, between Broken Bay and Port Jackson, 33°30'S 150°50'E to 33°50'S 152°03'E, 585 m, 9–10 October 1972, FRV *Kapala*, stns K72-05-09 to K72-05-11; 1 male, cl. 27.5 mm, AM P26771, south-east of Broken Bay, 33°40'S 151°56'E to 33°37'S 151°56'E, 732 m, 6 December 1977, FRV *Kapala*, stn K77-23-06; 1 male, cl. 19 mm, AM P39744, east of Long Reef Point, 33°47'S 151°10'E to 33°45'S 151°52'E, 503–567 m, 19 May 1983, FRV *Kapala*, stn K83-01-08; 1 male, cl. 28.5 mm, AM P40361, east of Port Jackson, 33°49'S 151°51'E to 33°45'S 151°52'E, 640 m, 30 April 1984, FRV *Kapala*, stn K84-06-01; 1 female, cl. 17 mm, AM P18996, north-east of Botany Bay, 34°00'S 151°43'E to 33°54'S 151°47'E, 720 m, 6 November 1972, FRV *Kapala*, stn K72-07-01; 1 female, cl. 25 mm, AM P25046, east of Wollongong, 34°24'S 151°25'E to 34°23'S 151°25'E, 720–756 m, 13 December 1976, FRV *Kapala*, stn K76-23-01; 1 female, cl. 39 mm, AM P38726, north-east of Shoalhaven Bight, 34°42'S 151°16'E to 34°38'S 151°18'E, 760–855 m, 3 December 1987, FRV *Kapala*, stn K87-23-03; 1 male, cl. 30.5 mm, 1 female, cl. 31.5 mm, AM P40362, east of Gerringong, 34°45'S 151°15'E, 732–786 m, 4 July 1989, FRV *Kapala*, stn K89-14-02.

**Remarks.** These specimens show little difference from Bate's (1888) description and figures of *Stereomastis suhmi*. There are two rostral spines and a sharp spine on the internal orbital angle. The orbital notch is smooth, subtriangular and deep; there is no spine at the external orbital angle.

The spinal formula of the lateral edge of the carapace is 4–6:2:8–10, most commonly 5:2:8. The spine forming the anterolateral angle of the carapace is larger than the following lateral spines and inwardly curved. The mid-



Fig. 12. *Stereomastis suhmi* (Bate), female, cl. 25 mm, AM P25046, dorsal view.

dorsal carina of the carapace (excluding the rostral spines) has a spine formula of 1,1,2,1 before the cervical groove and 2,2,2 behind the groove. Sund (1920) pointed out that the two small spines on the mid-dorsal carina behind the cervical groove, figured by Bate as single spines, are in fact paired in all of the *Challenger* type specimens. The crest of the posterior border of the carapace is granulate except for two spines, one on each side of the mid-dorsal carina.

The gastro-orbital ridge is formed by three or four small spines, the first the largest, in an oblique row



Fig. 13. *Stereomastis suhmi* (Bate), female, cl. 25 mm, AM P25046, carapace.

starting just behind the orbital notch; there is a cluster of spinules on the gastric region of the carapace as well as two or three small spinules laterally just behind the junction of the two branches of the cervical groove. The superior branchial carina is composed of seven to nine (most often eight) spinules.

The carina of abdominal segments 1 to 5 is produced into an antrorse spine; on segments 2 to 5 there is a cusp on the posterior part of the spine, low and smooth (seemingly worn) in some specimens, strong and sharp in others. The carina of the sixth segment is a double row of strong denticles. The telson has two strong denticles, one behind the other. The mid-anterior margin of the second abdominal pleuron is produced into a strong spine.

The merus of the cheliped has one or two fine spinules on the upper proximal margin.

One specimen, a 27.5 mm male (AM P26771), has three, rather than two, pairs of spines on the mid-dorsal carina. Two of the three pairs are very close together. In all other respects this specimen is a typical *S. suhmi*.

**Colour.** (Based on AM P25046). Carapace, abdominal segments and telson a uniform pale whitish pink; all spines of carapace and abdominal terga a darker rose pink. Endopods and inner three-quarters of exopods of

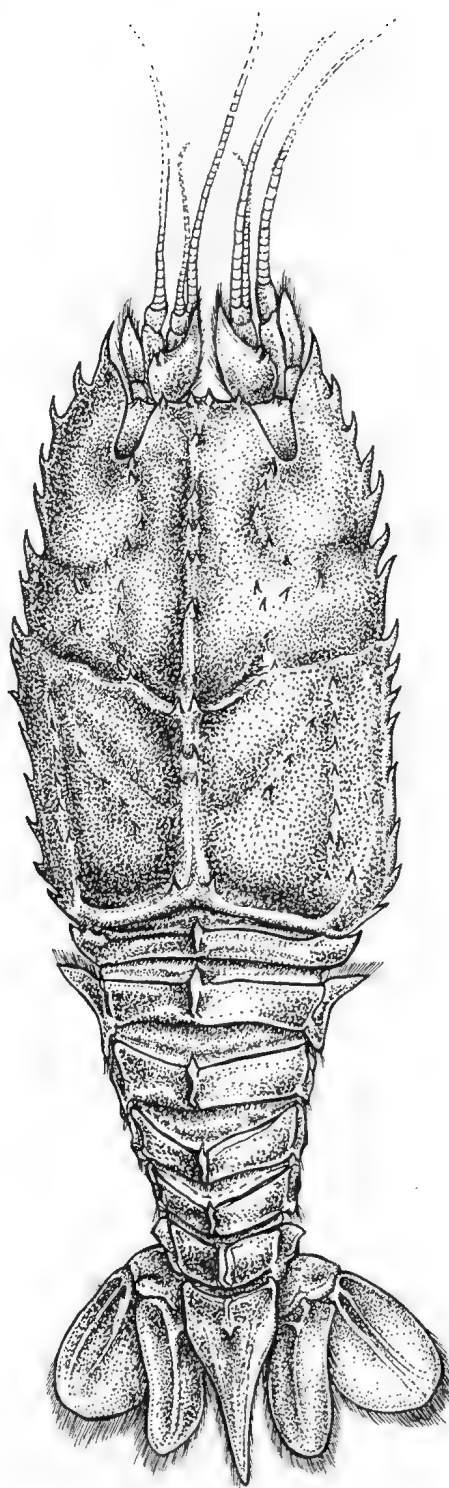


Fig. 14. *Stereomastis suhmi* (Bate), female, cl. 25 mm, AM P25046, dorsal view.



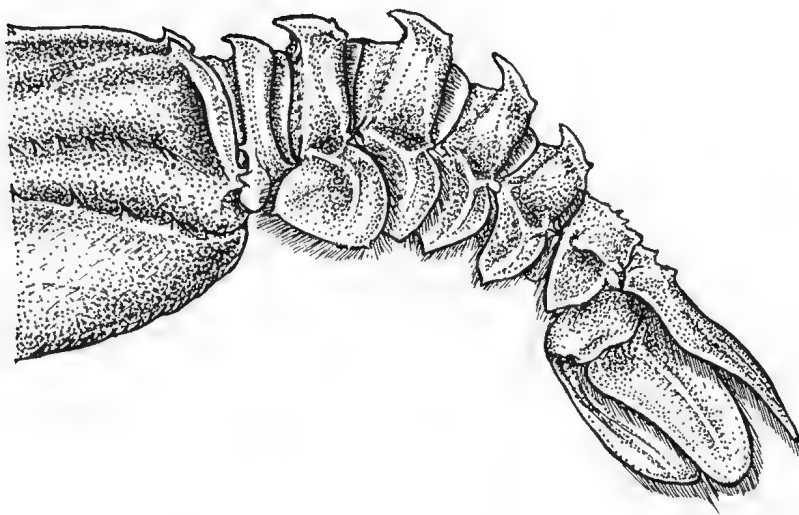


Fig. 15. *Stereomastis suhmi* (Bate), female, cl. 25 mm, AM P25046, lateral view of abdomen.

uropods whitish (almost transparent), entire outer edge of exopods trimmed in dark rose pink.

Ischium, anterior portion of merus and palm of propodus of cheliped pale, almost white; distal end of merus and carpus pale pink; fingers of cheliped also pale pink, fading to white at tips.

**Distribution.** South Atlantic Ocean: South Africa (Cape Point); western Pacific Ocean: south-eastern Australia; south-eastern Pacific Ocean: south-western coast of South America (west coast of Patagonia, coast of Chile); 293–2195 m.

#### *Willemoesia* Grote, 1873

The genus contains eight species, of which only one is known from the Indo-West Pacific region. One species, *Willemoesia leptodactyla* (Willemoes-Suhm, 1873) has been reported from Australia, but this material is shown here to be *W. bonaspei* Kensley, 1968.

#### *Willemoesia bonaspei* Kensley

Figs 16,17

*Willemoesia leptodactyla*. Bage, 1938: 9. (Not *W. leptodactyla* [Willemoes-Suhm, 1873]).

*Willemoesia bonaspei* Kensley, 1968: 294, figs 4, 5.—Kensley, 1981: 29.—Gore, 1984: 6 (table 2).

**Material examined.** One male, cl. 50 mm, total length 112 mm, AM P11316, south-west of Eyre Peninsula, South Australia, Great Australian Bight, 35°55.5'S 134°18'E, 3240 m, Station 13, Australasian Antarctic Expedition, 1911–1914, 24 February 1914.

**Description.** Although this specimen is not from eastern Australia it is included here because the single specimen described by Bage (1938) as *W. leptodactyla* is the only record of the genus from Australian waters and Bage's description of it was very brief.

Dorsal surface of carapace covered by numerous small, forwardly curved spinules. Rostral spine single, large (tip broken). Frontal margin of carapace produced, with a strong spine on internal orbital angle. Anterolateral angle of carapace formed by a large spine, the largest on the carapace; carapace in profile is slightly arched. Basal segment of antennular peduncle serrate along its medial edge, no spines or spinules on antero-external angle.

Spine formula of lateral edges of carapace 8–9:6:23–25. Spine formula of mid-dorsal carina (excluding the rostral spine) 1,1,1,2,1,1 before the cervical groove; irregularly paired spinules arranged irregularly behind groove, two or three slightly more prominent than others. Posterior edge of carapace smooth. Gastro-orbital carinae of carapace prominent and bearing spinules of the same kind as on rest of carapace. Superior branchial carina bearing 20–23 spines and spinules.

Abdominal terga smooth, with terga 2 to 4 bearing faint obliquely transverse grooves. All terga with a mid-dorsal carina; carinae of terga 1 to 4 culminating in an antrorse spine; spine of the fourth tergum reduced; dorsal surface of the first to third carinae slightly uneven; fifth carina a low blunt ridge; sixth carina a smooth hump. Surface of abdominal pleura smooth with weakly elevated curved ridges mesially; edges unarmed. Telson longer than uropods and sharply pointed. (Chelipeds missing from the specimen).

**Remarks.** Bate (1888) based his description of *W. leptodactyla* on a female specimen taken at *Challenger*

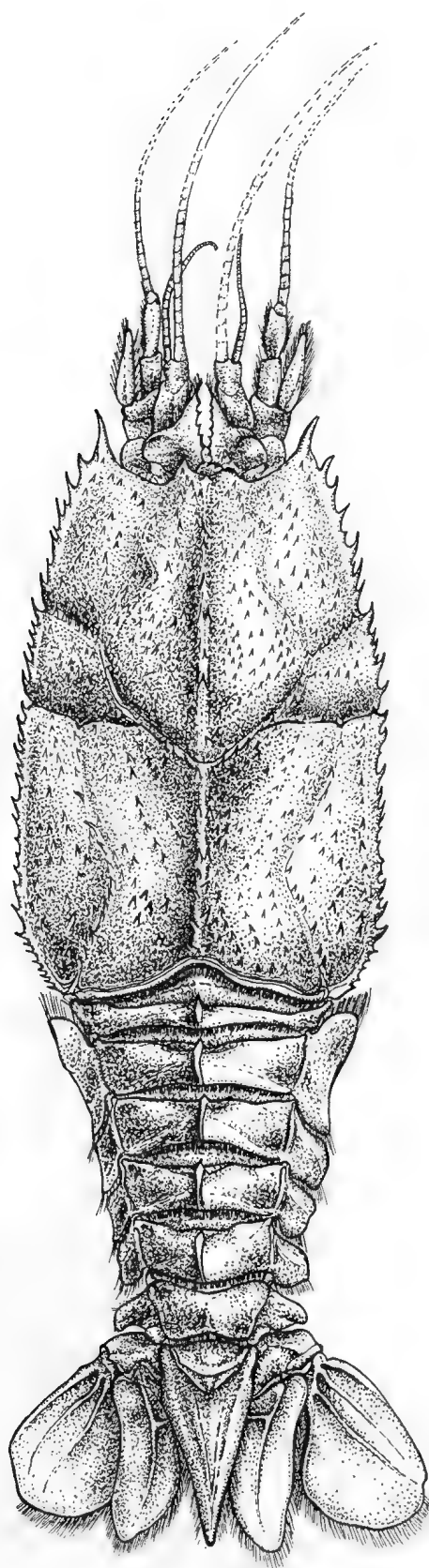


Fig. 16. *Willemoesia bonaspei* Kensley, male, cl. 50 mm, AM P11316, dorsal view.

station 13 (mid North Atlantic Ocean) and figured on plates 18 and 19C". Bate also briefly discussed what he called a "... decided variety of *Willemoesia leptodactyla*", a large male specimen collected at *Challenger* station 300 (off Valparaiso, south-east Pacific Ocean). The anterior portion of the dorsal carapace of this specimen is illustrated on plate 19 figure C (Bate, 1888). Sund (1920) made this specimen the type of a new species, *W. pacifica*. Kensley (1968) described *W. bonaspei* from off south-western South Africa. Bage's (1938) southern Australian specimen is clearly not *W. leptodactyla* but is very close to both *W. pacifica* and *W. bonaspei*. The overall length of the specimen, the finely spinulose dorsal surface, the number of spines on the lateral margins of the carapace, and the presence of tiny spines on the branchial ridge match both *W. pacifica* and *W. bonaspei*.

The shape of the frontal margin is more similar to that of *W. bonaspei* than to *W. pacifica*, especially the distinctly concave inner margins of the two large submedian spines. The spination of the mid-dorsal carina of the carapace fits to the range given for *W. bonaspei*, but not so well to that of *W. pacifica*. Sund (1920: 223) described the first abdominal somite of *W. pacifica* as having dorsally "a well-developed hook"; both *W. bonaspei* and Bage's specimen have a small forwardly-directed tooth.

This species is very close to *W. pacifica* and, as suggested by Kensley, may be found to be synonymous with it when more material becomes available.

**Distribution.** South-eastern Atlantic Ocean: west of Cape Point, South Africa; western Pacific Ocean: southern Australia; 2800–3520 m.

## Family SCYLLARIDAE

### *Ibacus* Leach, 1815

The genus contains six species, all known from the Indo-West Pacific region. Five species have been reported from Australia: *Ibacus alticrenatus* Bate, 1888, from western and north-western, eastern and southern Australia (Grant, 1905; George & Griffin, 1972; Holthuis, 1985; Wadley & Evans, 1991); *I. brucei* Holthuis, 1977, from eastern Australia (Holthuis, 1977, 1985); *I. ciliatus pubescens* Holthuis, 1960, from north-western Australia (Holthuis, 1985; Wadley & Evans, 1991); *I. novemdentatus* Gibbes, 1850, from western and north-western Australia (Phillips *et al.*, 1981; Holthuis, 1985); *I. peronii* Leach, 1815, from south-western, southern and south-eastern Australia (many authors, summarised in Holthuis, 1985).

*Ibacus brucei* has been taken in New South Wales waters by the FRV *Kapala*, but it has not been recorded below 190 m.



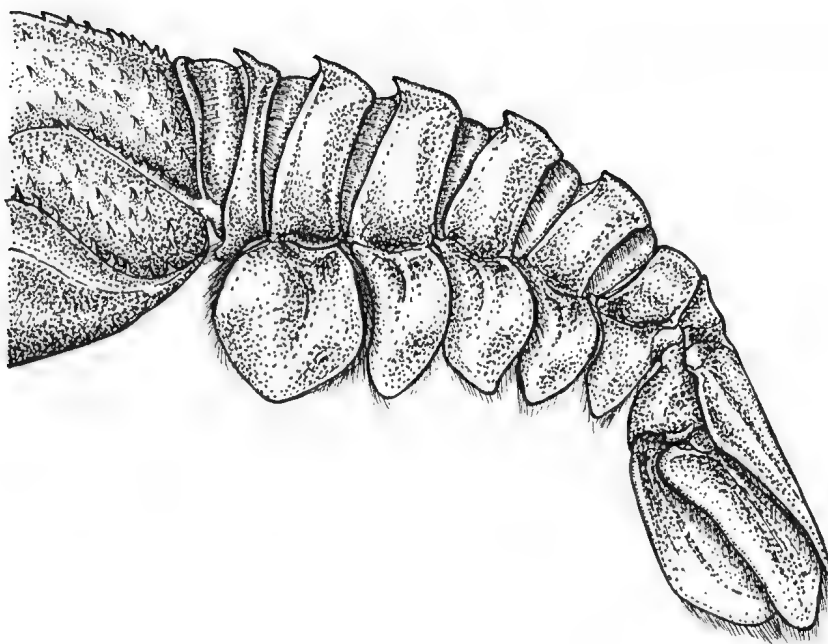


Fig. 17. *Willemoesia bonaspei* Kensley, male, cl. 50 mm, AM P11316, lateral view.

### *Ibacus alticrenatus* Bate

*Ibacus alticrenatus* Bate, 1888: 63, pl. 9 fig. 2.  
*Ibacus alticrenatus*.—Powell, 1947: 37, fig. 184.—Dell, 1955: 148.—Yaldwyn, 1961: 3 (key).—Holthuis, 1985: 23 (key), 36, fig. 9.—Holthuis, 1991: 197 (key), 200, figs 376,382.  
*Ibacus alticrenatus septemdentatus* Grant, 1905: 322, pl. 11 fig. 1.  
*Ibacus alticrenatus*.—George & Griffin, 1972: 228.

**Material examined.** One ovigerous female, cl. 44 mm, 1 female, cl. 42 mm, 1 male, cl. 43 mm, AM P17911, east of Port Stephens, 32°46'S 152°42'E, 585–576 m, 7 May 1971, FRV *Kapala*, stn K71-09-01; 1 female, cl. 36 mm, AM P17908, north-east of Port Jackson, 33°41'S 151°55'E to 33°44'S 151°53'E, 540 m, 20 April 1971, FRV *Kapala*, stn K71-07-01; 4 females, cl. 37.5–43.5 mm, 3 males, cl. 25.5–37 mm, AM P18987, east of Port Jackson, 33°44'S 151°48'E to 33°48'S 151°45'E, 162 m, 10 August 1972, FRV *Kapala*, stn K72-02-13; 3 females, cl. 19–39 mm, 1 male, cl. 33.5 mm, AM P17964, south-east of Port Hacking, 33°15'S 151°25'E to 34°20'S 151°21'E, 261–279 m, 28 June 1971, FRV *Kapala*, stn K71-10-02; 1 male, cl. 33 mm, AM P17968, north-east of Jervis Bay, 34°56'S 151°06'E to 35°02'S 151°05'E, 300–297 m, 8 July 1971, FRV *Kapala*, stn K71-11-08; 1 male, cl. 16 mm, AM P19620, east of Port Jackson, 33°51'S 151°51'E to 33°15'S 151°55'E, 680 m, 19 October 1972, FRV *Kapala*, stn K72-06-03.

**Remarks.** *Ibacus alticrenatus* is well described and figured by Bate (1888) and Holthuis (1985).

**Distribution.** South-west Pacific Ocean: south-eastern Australia, New Zealand; 20–680 m, mainly between 175 and 540 m.

### *Scyllarus* Fabricius, 1775

The genus contains about 40 species, 26 of which are known from the Indo-West Pacific region. Most are shallow-water species. One species, *Scyllarus mawsoni* (Bage, 1938), has been reported from deep water off south-eastern Australia.

### *Scyllarus mawsoni* (Bage)

*Arctus mawsoni* Bage, 1938: 10, pl. 4 figs 2,2a.  
*Scyllarus mawsoni*.—Hale, 1941: 272, pl. 3 figs 1,2.—Holthuis, 1946: 88.

**Material examined.** One ovigerous female, cl. 24.5 mm, 2 males, cl. 12 and 13 mm, AM P24397, AM P24396, north-east of Brush Island, 35°29'S 150°47'E to 35°32'S 150°45'E, 324 m, 8 June 1976, *Kapala*, K76-08-01; 4 females, cl. 17.5–18.5 mm, 1 male, cl. 15 mm, AM P25040, east of Brush Island, 35°30'S 150°45'E to 35°32'S 150°44'E, 324 m, 10 November 1976, FRV *Kapala*, stn K76-19-01; 2 females, cl. 15 and 17 mm, AM P25031, east of Brush Island, 35°32'S 150°45'E to 35°34'S 150°43'E, 270 m, 1 December 1976, FRV *Kapala*, stn K76-22-03; 1 ovigerous female, cl. 19 mm, AM P25043, 20 miles south of Lawrence Rocks, Portland, Victoria [approx. 38°21'S 141°36'E], 182–219 m, May 1976.

**Remarks.** Bage's (1938) original description of this species is very brief, and her figures do not show much detail. Hale (1941) made some additional comments and gave additional figures but the species is at present still inadequately described and figured. Dr Holthuis is dealing with this species in a forthcoming paper.

**Distribution.** South-west Pacific Ocean: south-eastern and southern Australia; 108–540 m.

### Discussion

The lobster fauna comprises three groups: shallow-water tropical reef forms, especially species of *Panulirus* (spiny or rock lobsters); a variety of other species—mostly temperate shallow-water forms of palinurids and scyllarids; and a variety of deep-sea species. The twenty-three species reported here bring the total number of species of deep-sea lobsters known from Australia to thirty-five, increasing the known archibenthal fauna by ten species.

The deep-sea lobsters of Australia clearly constitute a typical archibenthal fauna, the genera represented and their zoogeographic affinities being essentially those found in the archibenthal lobster faunas of other regions. Twenty-five (71%) of the thirty-five species are contained in five (38%) genera (*Metanephrops*, *Nephropsis*, *Polycheles*, *Stereomastis* and *Ibacus*).

Of the 35 species recorded from Australia, 8 are

known only from Australia; 19 from Australia and other Indo-West Pacific areas; 5 from Australia, the Indo-West Pacific and Atlantic Oceans; one from Australia, the Indo-West Pacific and North Central Pacific Ocean; one from Australia, the eastern Pacific and Atlantic Oceans; and one from Australia and the Atlantic Ocean. So far as it is known, the Australian deep-water lobster fauna is predominantly part of the general Indo-West Pacific fauna. Its outlying connections with the Atlantic Ocean are mostly via south-western Africa rather than via the eastern Pacific Ocean and southern South America.

Of the seven Australian species also known from the Atlantic Ocean, three (*Polycheles granulatus*, *P. typhlops* and *Stereomastis sculpta*) are geographically very widespread in both the Atlantic and Indo-West Pacific Oceans; the other four (*Projasus parkeri*, *Stereomastis nana*, *S. suhmi* and *Willemoesia bonaspei*) have a southern distribution, their Atlantic Ocean records all being from off south-western Africa. Only two of the eastern Australian deep-water lobster species (*Projasus parkeri* and *Ibacus alticrenatus*) are also found in New Zealand. The distribution of all reported Australian species is summarised in Table 1.

### Key to species of lobsters recorded from Australian waters below 200 meters

(Based largely on keys provided in Holthuis [1991], Chan & Yu [1991] and Macpherson [1993])

1. Pereopod 3 chelate ..... 2
- Pereopod 3 not chelate ..... 15
2. Pereopod 4 not chelate ..... 3
- Pereopod 4 chelate ..... 25
3. Telson without spines. Eyes strongly reduced, without pigment. Chelipeds very unequal, the larger with fingers more than 4 times as long as palm ..... *Thaumastochelopsis wardi* Bruce
- Telson with lateral and/or postlateral spines. Eyes well developed or reduced. Chelipeds equal or unequal, fingers less than 2 times as long as palm ..... 4
4. Rostrum laterally compressed for most of its length, with dorsal teeth (ventral teeth present, lateral teeth absent). Carapace with branchiostegal spine. Lateral margins of telson with 6–12 spines ..... *Acanthacaris tenuimana* (Bate)
- Rostrum dorsoventrally compressed, without dorsal teeth (ventral and lateral teeth present or absent). Carapace without branchiostegal spine. Lateral margins of telson with 3 or less small irregular spines ..... 5

5. Scaphocerite absent. Carapace without postorbital spine.  
Abdominal sternites unarmed in both sexes. Second maxilliped  
without podobranch ..... 6
- Scaphocerite present. Carapace with distinct postorbital spine.  
Abdominal sternites 2 to 5 in male each with a sharp median  
spine. Second maxilliped usually with podobranch ..... 11
6. Exopod of uropod with a diaeresis ..... *Nephropsis suhmi* (Bate)
- Exopod of uropod without a diaeresis ..... 7
7. Dorsal surface of telson with a well-developed spine ..... *Nephropsis acanthura* Macpherson
- Dorsal surface of telson without a well-developed spine ..... 8
8. Rostrum with two pairs of lateral spines ..... *Nephropsis sulcata* Macpherson
- Rostrum with one pair of lateral spines ..... 9
9. Abdominal somites with a median dorsal carina ..... *Nephropsis holthuisi* Macpherson
- Abdominal somites without a median dorsal carina ..... 10
10. Carapace with subdorsal carinae granular ..... *Nephropsis stewarti* Wood-Mason
- Carapace with at least 3 with well-developed spines on each  
subdorsal carina ..... *Nephropsis serrata* Macpherson
11. Carapace smooth between the ridges and large spines ..... 12
- Carapace rather uniformly spinose ..... 14
12. Chelae of first pereopods heavily ridged and spinulose  
..... *Metanephrops velutinus* Chan & Yu
- Chelae of first pereopods weakly ridged and finely granular ..... 13
13. First pereopod with distinct spine in middle of inner margin  
of merus. Posterior margin of cervical groove with 4–7  
spinules ..... *Metanephrops boschmai* (Holthuis)
- First pereopod without a distinct spine in middle of inner  
margin of merus. Posterior margin of cervical groove  
smooth ..... *Metanephrops sibogae* (de Man)
14. Region of carapace between postrostral carinae heavily  
spinulose ..... *Metanephrops neptunus* (Bruce)
- Region of carapace between postrostral carinae smooth *Metanephrops australiensis* (Bruce)
15. Antennal flagellum reduced to a single broad flat segment,  
similar to the peduncular segments ..... 16
- Antennal flagellum long, multi-articulate ..... 20

16. Exopods of all maxillipeds with a multi-articulate flagellum. Carapace strongly depressed dorsoventrally. Lateral margin of carapace with deep cervical incision, without postcervical incision ..... 17
- Exopod of third and first maxilliped without a flagellum; flagellum of second maxilliped a single laminate segment. Carapace not strongly depressed dorsoventrally, rather high and vaulted. Lateral margin of carapace with shallow cervical and postcervical incisions ..... *Scyllarus* spp.
17. Merus of third maxilliped with ventral surface slightly concave, not swollen; inner margin sometimes crenulate but not with deep incisions ..... 18
- Merus of third maxilliped swollen; inner margin with deep incisions ..... 19
18. Cervical incision wide, anterior margin forming posterior margin of anterolateral angle of carapace, thus no lateral margin between the anterolateral angle and the cervical incision. Carapace with 7–9 posterolateral teeth ..... *Ibacus alticrenatus* Bate
- Cervical incision narrow, anterior margin reaching lateral margin some distance behind the anterolateral angle; toothed lateral margin present between the anterolateral angle and the cervical incision. Carapace with 11–13 posterolateral teeth ..... *Ibacus ciliatus pubescens* Holthuis
19. Anterior teeth of epistome directed forwards. Posterior branchial carinae of carapace straight or only slightly convex, lying in one line with anterior branchial carinae. Posterior incision of orbit without tubercle. Lateral margin of carapace with 8 (rarely 7) posterolateral teeth ..... *Ibacus novemdentatus* Gibbes
- Anterior teeth of epistome directed ventrally. Posterior branchial carinae of carapace strongly convex, not lying in one line with anterior branchial carinae. Posterior incision of orbit with distinct tubercle. Lateral margin of carapace with 6 or 7 (rarely 8) posterolateral teeth ..... *Ibacus peronii* Leach
20. Epistome long, about 1/3 carapace length. Eyes on a median elevation of the cephalon ..... *Neoglyphea inopinata* Forest & de Saint Laurent
- Epistome short, much less than 1/3 carapace length. Eyes not on elevation of the cephalon ..... 21
21. Frontal horns fused to form a broad 2- or 4-spined median projection on anterior margin of carapace between the eyes. Antennal flagella straight, inflexible ..... 22
- Two distinct widely separated frontal horns present, with anterior margin visible between them. Antennal flagella flexible ..... 23

22. Epistomal ridges coarsely granular, without an acute well-developed anterior tooth. Chitinous margin of male genital aperture with toothed median border and smooth lateral border ..... *Linuparus sordidus* Bruce
- Epistomal ridges weakly granular, with an acute well-developed anterior tooth. Chitinous margin of male genital aperture toothed throughout its length ..... *Linuparus trigonus* (von Siebold)
23. Antennular plate distinct; a stridulating organ present. Carapace with median ridge behind the cervical groove; often with spines or tubercles but without submedian ridges ..... 24
- Antennular plate hardly, if at all, visible in dorsal view; stridulating organ absent. Carapace without a median ridge behind cervical groove; with 2 submedian ridges, each bearing a row of large, sharply pointed teeth or numerous spinules ..... *Projasus parkeri* (Stebbing)
24. Postorbital spine present. Median keel of carapace without teeth, with 6 postcervical and 6 intestinal tubercles. Tubercles on carapace low and mostly obscured by pubescence. Eyes large, much broader than long ..... *Puerulus velutinus* Holthuis
- Postorbital spine absent. Median keel of carapace with 3–5 postcervical and 2–4 intestinal teeth. Tubercles on carapace distinct, not obscured by pubescence. Eyes small, longer than broad ..... *Puerulus angulatus* (Bate)
25. Frontal margin of carapace with 1 rostral spine ..... 26
- Frontal margin of carapace with 2 rostral spines ..... 27
26. Anterior margin of carapace with deep V-shaped orbital notches divided into two parts by interlocking spines on the margins. Posterior margin of carapace spinose ..... *Polycheles typhlops* Heller
- Anterior margin of carapace without deep orbital notches, with broad shallow non-spinose excavations. Posterior margin of carapace smooth ..... *Willemoesia bonaspei* Kensley
27. Lateral borders of carapace with more than 20 spines ..... 28
- Lateral borders of carapace with less than 20 spines ..... 30
28. Posterior margin of carapace smooth ..... *Polycheles granulatus* Faxon
- Posterior margin of carapace spinose ..... 29
29. Anterior margin of carapace spinose between outer angle of orbital notch and anterolateral spine. Lateral margin of carapace, between postcervical groove and posterior margin, with 20–25 spines ..... *Polycheles baccatus* Bate
- Anterior margin of carapace smooth, without spines, between outer angle of orbital notch and anterolateral spine. Lateral margin of carapace, between postcervical groove and posterior margin, with 13–16 spines ..... *Polycheles euthrix* (Bate)

30. Mid-dorsal carina of carapace, between rostral spines and cervical groove, with spine formula 1,1,2,1 ..... 31
- Mid-dorsal carina of carapace, between rostral spines and cervical groove, with spine formula 1,2,1 ..... *Stereomastis sculpta* (Smith)
31. Dorsal carinae of abdominal segments 1 to 5 produced into an anteriorly projecting hook ..... 32
- Dorsal carinae of abdominal segments 1 to 4 produced into an anteriorly projecting hook ..... *Stereomastis phosphorus* (Alcock)
32. Anterior margin of carapace with small spine at inner angle of orbital notch ..... *Stereomastis andamanensis* (Alcock)
- Anterior margin of carapace without spine at inner angle of orbital notch ..... 33
33. Anteroventral margin of second abdominal pleuron broadly rounded ..... *Stereomastis nana* (Smith)
- Anteroventral margin of second abdominal pleuron excavate ..... *Stereomastis helleri* (Bate)

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**Table 1.** Geographical distribution of Australian deep-sea lobsters. AO: Atlantic Ocean; IO: Indian Ocean; In: south-east Asia, from South China Sea to Indonesia; WA: western and western southern Australia; EA: eastern and eastern southern Australia; WP: western Pacific Ocean other than eastern Australia; CP: north-central Pacific Ocean; EP: eastern Pacific Ocean.

Geographic region:	AO	IO	In	WA	EA	WP	CP	EP
GLYPHEIDAE								
<i>Neoglyphea inopinata</i>	—	—	×	×	—	—	—	—
NEPHROPIDAE								
<i>Acanthacaris tenuimana</i>	—	×	×	—	×	×	—	—
<i>Metanephrops australiensis</i>	—	—	—	×	—	—	—	—
<i>Metanephrops boschmai</i>	—	—	—	×	—	—	—	—
<i>Metanephrops neptunus</i>	—	—	—	×	—	—	—	—
<i>Metanephrops sibogae</i>	—	—	×	×	×	—	—	—
<i>Metanephrops velutinus</i>	—	—	×	×	×	—	—	—
<i>Nephropsis acanthura</i>	—	×	×	×	×	×	—	—
<i>Nephropsis holthuisi</i>	—	—	—	×	×	—	—	—
<i>Nephropsis serrata</i>	—	—	—	×	—	—	—	—
<i>Nephropsis stewarti</i>	—	×	×	×	—	×	—	—
<i>Nephropsis suhmi</i>	—	×	×	—	×	×	—	—
<i>Nephropsis sulcata</i>	—	×	×	—	×	×	—	—
PALINURIDAE								
<i>Linuparus sordidus</i>	—	—	—	×	×	×	—	—
<i>Linuparus trigonus</i>	—	—	—	×	×	×	—	—
<i>Projasus parkeri</i>	×	×	—	—	×	×	—	—
<i>Puerulus angulatus</i>	—	×	×	×	×	×	—	—
<i>Puerulus velutinus</i>	—	—	×	×	—	—	—	—
POLYCHELIDAE								
<i>Polycheles baccatus</i>	—	—	×	—	×	×	—	—
<i>Polycheles euthrix</i>	—	—	—	—	×	×	—	—
<i>Polycheles granulatus</i>	×	×	—	—	×	×	—	—
<i>Polycheles typhlops typhlops</i>	×	×	—	—	×	×	—	—
<i>Stereomastis andamanensis</i>	—	×	×	—	×	—	—	—
<i>Stereomastis helleri</i>	—	—	—	—	×	×	—	—
<i>Stereomastis phosphorus</i>	—	×	—	×	×	—	×	—
<i>Stereomastis nana</i>	×	—	—	×	—	×	—	—
<i>Stereomastis sculpta</i>	×	—	×	—	×	—	—	—
<i>Stereomastis suhmi</i>	×	—	—	—	×	—	—	×
<i>Willemoesia bonaspei</i>	×	—	—	—	×	—	—	—
SCYLLARIDAE								
<i>Ibacus alticrenatus</i>	—	—	—	×	×	×	—	—
<i>Ibacus ciliatus pubescens</i>	—	—	×	×	—	—	—	—
<i>Ibacus novemdentatus</i>	—	×	×	×	—	×	—	—
<i>Ibacus peronii</i>	—	—	—	×	×	—	—	—
<i>Scyllarus mawsoni</i>	—	—	—	—	×	—	—	—
THAUMASTOCHELIDAE								
<i>Thaumastochelopsis wardi</i>	—	—	—	—	×	—	—	—



## A Taxonomic Revision of the *Cyclodomorphus branchialis* Species Group (Squamata: Scincidae)

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**ABSTRACT.** The *Cyclodomorphus branchialis* species group is defined on synapomorphies of scalation. Within this complex, five allopatric species, one with three subspecies, are recognised on morphological grounds: *C. branchialis* (Günther) of the lower west coast and hinterland, *C. maximus* (Storr) of the Kimberley, *C. melanops melanops* (Stirling & Zeitz) widespread in spinifex habitats of the arid north-west, and *C. m. elongatus* (Werner) widespread in spinifex habitats of the arid south and east of the continent, together with two new species, one from the lower west coast and the other from South Australia, and a new subspecies of *C. melanops* from chenopod habitats along the southern fringe of the Nullarbor Plain. The morphology, distribution, habitat preferences and reproduction of the seven taxa are described. All primary type specimens are illustrated. A key to the species and subspecies in the genus *Cyclodomorphus* is provided. *Cyclodomorphus branchialis*, considered on previous taxonomic opinion to be widespread in arid Australia, is restricted to a small area in Western Australia and is considered vulnerable.

SHEA, GLENN M. & BRIAN MILLER, 1995. A taxonomic revision of the *Cyclodomorphus branchialis* species group (Squamata: Scincidae). Records of the Australian Museum 47(3): 265–325.

Closely allied to the large bluetongue skinks of the genus *Tiliqua* Gray, 1825 is a group of smaller species that have variously been considered as congeneric with *Tiliqua*, or placed in a separate genus, for which the names *Omolepida* Gray, 1845 or *Cyclodomorphus* Fitzinger, 1843 have been used (Shea, 1990). Two of the species of *Cyclodomorphus*, *C. casuarinae* (Duméril & Bibron, 1839) and *C. gerrardii* (Gray, 1845) are readily identifiable and confined to the moist coast and ranges of eastern Australia (see Shea [1995] for a

revision of variation in the former species, and the recognition of two new species). The remaining taxa within *Cyclodomorphus* are inhabitants of the dry interior and west coast of Australia, and have posed taxonomic problems for over a century. This latter group, differentiated from the other *Cyclodomorphus* species by having broadly contacting nasal scales, separated prefrontal scales, a distinct postnarial groove and paravertebral scales much broader than adjacent dorsal body scales, is here referred to as the *Cyclodomorphus*

*branchialis* species group. At least the first two characters are synapomorphies in the context of its relatives, the *Egernia* group of genera (Greer, 1979).

Boulenger (1887) recognised only one species in the *branchialis* group, *Lygosoma (Homolepida) branchiale* (Günther, 1867) from Western Australia, relegating the other described species, *Lygosoma muelleri* Peters, 1878, described from South Australia, to the synonymy of *L. casuarinae*. Stirling & Zeitz (1893) described a third taxon, *Lygosoma (Homolepida) melanops*, from northern South Australia but, following Boulenger (1887), the standard reference of that era, compared it only with *L. branchiale*. Boulenger (1898), without reference to Stirling & Zeitz (1893), described *Lygosoma gastrostigma* from north-west Western Australia.

Zeitz (1920), without explanation, referred *L. melanops* to the synonymy of *L. branchialis*, but retained *L. gastrostigma* as distinct. Sternfeld (1919, 1925) synonymised *L. gastrostigma* with *L. melanops*, and recognised that *Lygosoma muelleri* was both clearly distinct from *L. casuarinae* and *L. branchialis* and a junior homonym of *Scincus muelleri* Schlegel (1839) (then, as most skinks, in *Lygosoma*), and proposed *Lygosoma (Homolepida) petersi* as a replacement name, although basing his redescription on new material from Hermannsburg Mission, in the Northern Territory. The description by Werner (1910) of *Lygosoma branchiale* var. *elongatum* from a single specimen collected at Boorabbin, Western Australia, by Michaelsen and Hartmeyer's Hamburg expedition passed unnoticed by Sternfeld and Zeitz, and indeed by most subsequent authors, including Michaelson (1914) in a summary of the expedition's findings. Proctor (1923) described an insular species, *L. (H.) woodjonesii*, from Saint Francis Island, comparing it with *L. branchialis* and *L. gastrostigma*.

Sternfeld's and Zeitz's largely unsupported conclusions were criticised by Loveridge (1934, 1938), who resurrected *Lygosoma (Omolepida) melanops* from the synonymy of *L. branchialis* without explanation, placing *Lygosoma gastrostigma* in its synonymy, and reduced *Lygosoma petersi*, which he treated as a new species rather than a *nomen novum*, to a subspecies of *L. casuarinae*. The motivation for this latter action is unclear, but is possibly a reflection of Boulenger's (1887) earlier opinion. Smith (1937) listed only three species, *branchiale*, *gastrostigma* and *woodjonesi* [sic], when he transferred *Cyclodomorphus* (then *Lygosoma [Omolepida]*) to *Tiliqua*.

Mitchell (1950), in the first complete revision of the genus *Tiliqua* (in which he included *Cyclodomorphus*) since Boulenger (1887), reduced *L. woodjonesii* to a subspecies of *Tiliqua branchialis*, and placed both *L. melanops* and *L. gastrostigma* in the synonymy of *T. branchialis*, noting that he could find "no valid structural differences, the only variation being in coloration as is indicated by the various published descriptions... The colour variation does not appear to be correlated in any way with the other variable features, viz. the relative size of the ear opening, body proportions and distribution". However, he still retained *L. petersi* as a race of *T.*

*casuarinae* despite giving the type locality (incorrectly) as Hermannsburg Mission yet identifying specimens he had examined from this locality as *T. branchialis*.

Mitchell apparently subsequently changed his mind on the synonymy of *L. melanops*, for Warburg (1965) quotes a communication from Mitchell that his material listed in 1950 as *C. branchialis* should be *C. melanops*.

Glauert (1960, 1961) recorded three species from Western Australia, *Tiliqua branchialis*, which he restricted to the vicinity of the type locality, *T. melanops* from Perth through to South Australia, and *T. gastrostigma*, from the Pilbara, although noting that all were structurally almost identical and may only be subspecifically distinct. Worrell (1963) retained the same three species, together with *T. casuarinae petersi* and *T. woodjonesii*, although noting that further revision might result in the synonymy of *T. woodjonesii* and *T. c. petersi*.

Storr (1976) placed all previous names in the synonymy of *Omolepida branchialis*, and described a new species, *O. maxima*. This arrangement was accepted by Cogger (1979), although *Omolepida* was returned to the synonymy of *Tiliqua*.

Wells & Wellington (1984, 1985) recognised five species: *C. branchialis*, *C. gastrostigma* (confined to the west coast of Western Australia), *C. maxima*, *C. melanops* (confined to central Australia) and *C. woodjonesii* (confined to Nuyts Archipelago), but gave no justification for their taxonomy, which left a number of populations innominate.

Schwaner *et al.* (1985) recorded two species, *T. branchiale* [sic] and *T. melanops* on the Nuyts Archipelago and Eyre Peninsula respectively.

Most recently, Wilson & Knowles (1988) recognised four species in the complex: *C. branchialis*, *C. maxima*, *C. melanops* and an undescribed species, providing distribution maps for each of the described taxa, while Ehmann (1992) recognised only *C. branchialis* (including "*O. b. melanops*" and other "forms"), *C. maximus* and the undescribed species.

Our work on this group indicates that, contrary to the assertions of Mitchell (1950), body proportions, coloration and ear aperture size, together with body scalation, are geographically correlated, and the recent collection of several of these geographic forms in close proximity, though never in exact sympatry, suggests specific status.

## Materials and Methods

All specimens of the *C. branchialis* species group in Australian museum collections have been examined, together with all available type material and a few additional specimens in European and American collections, a total of over 1200 specimens. Collection abbreviations are Australian Museum, Sydney (AM), Australian National Wildlife Collection, Canberra (ANWC), Natural History Museum, London (formerly British Museum [Natural History]) (BMNH), Central Australian Wildlife Collection, Alice Springs (CAWC) (now lodged in Northern Territory Museum), H.F.W.



Ehmann private collection (to be lodged in SAM and WAM) (HFWE), Museum of Comparative Zoology, Harvard University, Massachusetts (MCZ), Museum of Victoria, Melbourne (MV), Naturhistorisches Museum, Vienna (NHMW), Northern Territory Museum, Darwin (NTM), Queensland Museum, Brisbane (QM), Senckenberg Museum, Frankfurt (SMF), South Australian Museum, Adelaide (SAM), Western Australian Museum, Perth (WAM), Zoologisches Museum, Berlin (ZMB) and Zoologisches Museum, Hamburg (ZMH).

Listed localities enclosed within quotation marks are property names. State names are abbreviated.

**Species and subspecies definitions.** The species and subspecies recognised in this revision are all geographically allopatric, and hence the biological species definition (Mayr, 1963) cannot be used. Further, the morphological characters that are used to define some species are of uncertain polarity due to variation among species in the most proximate outgroups (*Cyclodomorphus casuarinae* complex, *Cyclodomorphus gerrardii*, *Tiliqua* and *Egernia*), and hence the phylogenetic species concept (Frost & Hillis, 1990; Kluge, 1990), which defines species on the basis of synapomorphies, cannot be uniformly applied. Nonetheless, the geographic variation in morphological characters within the species-group is non-continuous, with abrupt discontinuities in the distribution of otherwise continuously varying characters, and the discontinuities in many characters are geographically concordant. We use the evolutionary species concept (Wiley, 1978) in recognising these morphological discontinuities as species boundaries.

In two cases, the geographic discontinuities in morphology are less clear-cut, either due to evidence of morphological intermediacy between two taxa in some part of the distribution, despite the maintenance of abrupt differences in other regions of geographic proximity, or to limited evidence of an abrupt but possibly continuous change over a short geographic distance between two otherwise homogeneous morphotypes. We recognise these two pairs of taxa as subspecies. In the latter case, between *C. melanops elongatus* and a newly described subspecies, synapomorphies of the temporal scalation and coloration link the two taxa. In the former case, however, between *C. m. melanops* and *C. m. elongatus*, there is as yet no evidence for monophyly of the two subspecies, and hence some workers may prefer to recognise these two taxa as species.

The diagnoses preceding each description list those characters which in combination distinguish the taxon. Further, more detailed comparisons between each taxon and those described before it are provided in comparisons with other taxa in each account.

**Geographic variation.** Within each of the geographically widespread taxa recognised in this study there is further geographic variation in morphology, in some instances involving characters used in diagnosing taxa. To further explore this geographic variation, we divided the overall

distribution of each taxon, based on the available samples, into smaller geographic units, which we term "populations". Available material was unevenly distributed, with large samples from some small areas, and small, scattered samples from other much larger areas. Consequently, some grouping of samples was unavoidable (Thorpe, 1976). In delimiting populations, we initially used geographic gaps between known localities. These may reflect real geographic discontinuities or a lack of collecting effort. In an attempt to avoid the second possibility, we preferentially used distributional discontinuities that reflected changes in geography, such as topographic features (drainage systems, ranges) or changes in vegetation or substrate. Adequately sampled insular populations were generally treated as discrete populations. Some residual large areas of homogeneous or gradually changing geography, lacking any clear gaps between localities, were arbitrarily sectioned into smaller units.

Geographic variation in scalational characters was explored by one-way analysis of variance, followed by pairwise comparison of means using Gabriel's approximation to the GT-2 method at a 5% level of significance (Sokal & Rohlf, 1981).

**Character definitions.** Head shield nomenclature follows Taylor (1935: 71). Head shields are counted on both sides, except for palpebrals, counted only on the left side, and are numbered from rostral to caudal. Where two figures are given for a specimen, the first figure is for the left side. Temporal scale configuration falls into one of two patterns. In all *Cyclodomorphus* species, the last supralabial is divided into an upper and lower scale, the upper scale thus forming a second "lower secondary temporal" (Shea, 1990). In members of the *C. branchialis* species group, this scale may be either of a height corresponding to the height of the primitive entire last supralabial, and permitting contact between the primary and true lower secondary temporal, here termed the  $\alpha$ -configuration, or may be of greater height, contacting the upper secondary temporal and preventing contact between the primary and true lower secondary temporal, here termed the  $\beta$ -configuration (compare Figs 7 and 24 respectively). The latter condition is apomorphic. In a few cases, the contact between the spurious lower secondary and upper secondary temporal is so broad that the  $\beta$ -configuration is not immediately obvious. However, even these cases can be identified by the upper secondary temporal overlapping four scales (vs three) along its ventral and caudal margins.

Midbody scales are counted around the body at the mid-point of the axilla-groin interval. Paravertebral scales are counted, generally on the left side, from the first scale caudal to the parietals, to the last scale cranial to the level of the cranial margin of the hindlimbs. Subcaudal scales are counted, on original tails only, from the cranialmost scale approximately equal in size to adjacent lateral caudal scales, caudal to and including the terminal caudal scale. Subdigital lamellae are counted

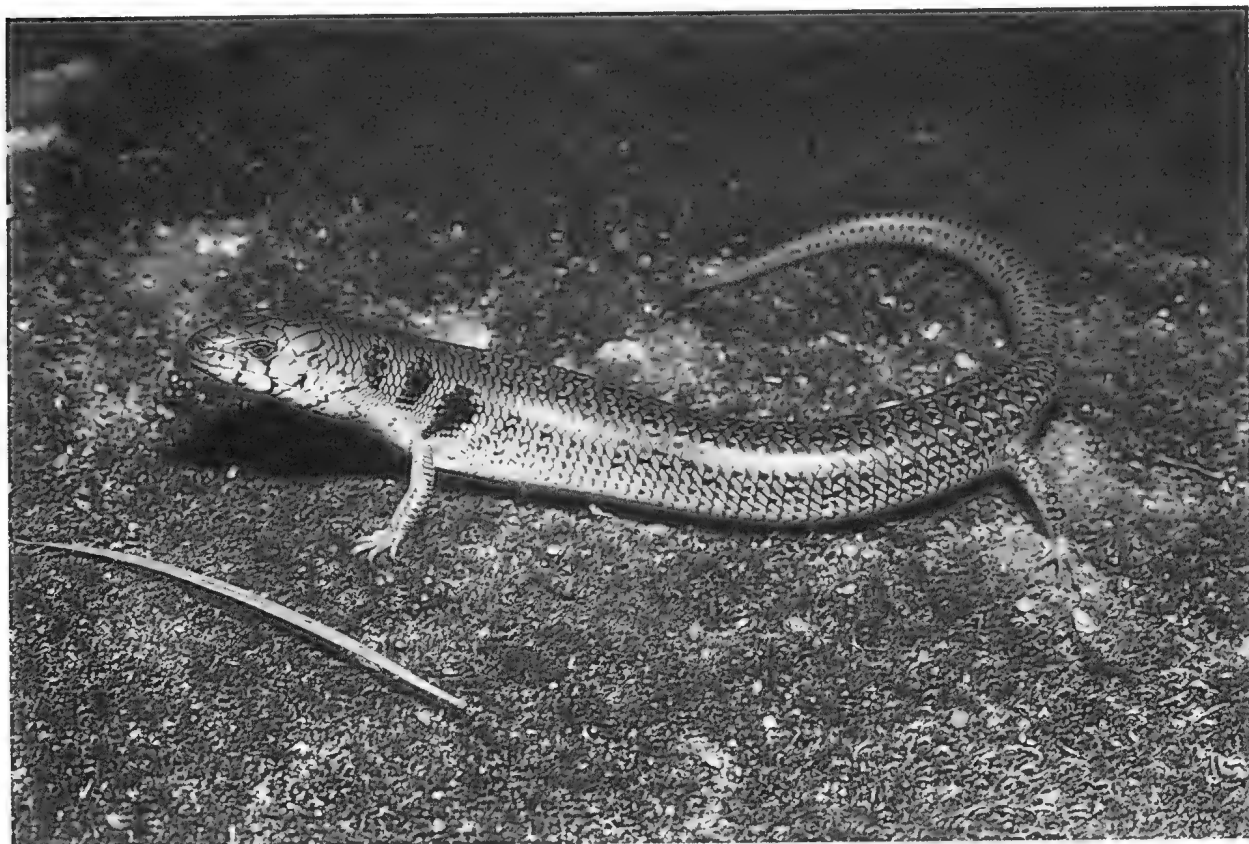


Fig. 1. A live *Cyclodomorphus branchialis* from Galena, WA.

bilaterally on the fourth toe from the first scale just beyond the edge of the sole, to and including the scale bordering the claw.

With individual exceptions as noted in taxon accounts, the following scalational characters of taxonomic importance in skinks were invariant in the *C. branchialis* species group: rostral projecting slightly between nasals; nasals in moderate to broad contact, widely separating rostral and frontonasal; nostril rostroventral in nasal; postnarial groove present but weak; supra- and postnasals absent; prefrontals moderately separated; frontal large, longer than wide, broadest rostrally; frontoparietals paired; parietal eye spot present, just caudal to centre of interparietal; loreals two bilaterally, subequal; supraoculars three, rostral two in contact with frontal, second largest; presuboculars two; lower eyelid scaly; primary temporal single; usually one, rarely two scales intercalated between upper secondary temporal and first pair of nuchals; first pair of chin shields in broad contact; second pair of chin shields separated medially by one scale; third pair of chin shields longitudinally divided, separated medially by three scales; body scales smooth; preanal scales subequal.

Non-cephalic measurements follow Greer (1982) and Cogger (1986). Head length is from the rostral margin of the ear to the tip of the snout; head width is across the widest point of the head, rostral to the ear, and head depth is vertically from the highest point of the parietal table. Head measurements were made with dial calipers

to the nearest 0.1 mm. All other measurements were made to the nearest 0.5 mm with a steel rule. The following measurement abbreviations are used throughout the text: SVL, snout-vent length; AGL, axilla-groin length; TL, tail length; FLL, forelimb length; HLL, hindlimb length; HL, head length; HW, head width; HD, head depth. Because of the significant allometry in all measurements, data are presented in two forms: the more traditional range of ratios, allowing comparison with previous studies, and allometric regressions, expressing the degree of allometry and allowing more detailed comparisons between sexes and taxa. Sexual dimorphism in metric characters was assessed by analysis of covariance, using the SYSTAT statistical package (Wilkinson, 1987).

In each taxon, most specimens for which date of collection was known, and which were larger than obviously immature material (less than approximately 60 mm), were sexed by gross examination of the gonads. Minimum mature size was taken as the smallest male with enlarged turgid testes or opaque vasa deferentia, and the smallest female with enlarged yolking ovarian follicles, unshelled oviducal eggs or embryos, and all sexed animals larger than the minimum mature size were assumed mature.

Growth rates are inferred in *C. celatus*, *C. m. melanops* and *C. m. elongatus* from the seasonal distribution of body sizes. This method is useful for species which show rapid growth and seasonal

reproduction (Shine, 1978), and indicated at least a clear first year cohort in the species studied here.

In summarising habitat data associated with specimens examined, we have only cited registration numbers for detailed data we have quoted. For less detailed data common to a number of records, only the sample size is given.

Subscripts give degrees of freedom for statistical tests, and the superscripts \*, \*\*, \*\*\* indicate significance at 5%, 1% and 0.1% levels respectively. T-tests and Mann-Whitney U tests are two tailed.

## Systematics

### *Cyclodomorphus branchialis* (Günther, 1867)

Figs 1–3

*Hinulia branchialis* Günther, 1867: 47.

**Diagnosis.** The smallest member of the species group (maximum known SVL 88 mm), *C. branchialis* differs from other members in the combination of a mode of 24 midbody scales, 62–70 paravertebral scales, 57–64 subcaudal scales, usually a  $\beta$ -configuration of the secondary temporal scales, three large, black, vertically ovoid patches on the sides of the neck between ear and axilla, and a yellow-brown to grey-brown or reddish dorsal ground colour.

**Description.** Postnarial groove rarely absent (11.1%,  $n = 9$ ); parietals completely separated by interparietal; interparietal broadest rostrally, approximately  $\frac{3}{4}$  length and breadth of frontal in adults, slightly larger in juveniles; transversely enlarged nuchals 0–4 on each side ( $\bar{x} = 2.8$ ,  $SD = 0.71$ ,  $n = 32$ ), usually three (71.9%); supraciliaries 5–7 ( $\bar{x} = 6.0$ ,  $SD = 0.45$ ,  $n = 36$ ), usually six (80.6%), first and last largest, third-last usually projecting between second and third supraocular, remainder moderate, subequal; postsuboculars 2–4 ( $\bar{x} = 2.6$ ,  $SD = 0.54$ ,  $n = 36$ ), usually three (58.3%), lower values often due to loss of uppermost postsubocular through fusion with last supraciliary; upper palpebrals 7–9 ( $\bar{x} = 8.1$ ,  $SD = 0.54$ ,  $n = 11$ ); lower palpebrals 7–10 ( $\bar{x} = 9.1$ ,  $SD = 1.04$ ,  $n = 11$ ); secondary temporals usually in  $\beta$ -pattern (86.1%,  $n = 36$ ), rarely in  $\alpha$ -pattern (13.9%); supralabials 7–8 ( $\bar{x} = 7.1$ ,  $SD = 0.29$ ,  $n = 34$ ), usually seven (91.2%), third-last below centre of eye, separating pre- and postsuboculars; infralabials 5–7 ( $\bar{x} = 6.2$ ,  $SD = 0.48$ ,  $n = 34$ ), usually six (73.5%); usually first two (84.8%,  $n = 33$ ), rarely first three, infralabials contacting postmental; ear small, approximately half height of eye, usually (94.1%,  $n = 34$ ) with a single small rounded lobule along rostral margin.

Body scales in 22–26 ( $\bar{x} = 24.1$ ,  $SD = 1.08$ ,  $n = 18$ ) longitudinal rows at midbody; scales in paravertebral rows much broader than adjacent lateral dorsal scales, 62–70 ( $\bar{x} = 65.2$ ,  $SD = 1.99$ ,  $n = 18$ ); subcaudal scales

57–64 ( $\bar{x} = 60.4$ ,  $SD = 2.12$ ,  $n = 11$ ); lamellae below fourth toe 9–12 ( $\bar{x} = 10.8$ ,  $SD = 0.72$ ,  $n = 32$ ), each with a narrow to broad light to mid-brown callus.

SVL 51–88 mm; AGL/SVL 52.6–63.9% ( $\bar{x} = 58.5\%$ ,  $n = 17$ ), TL/SVL 69.6–87.3% ( $\bar{x} = 81.2\%$ ,  $n = 10$ ); FLL/SVL 15.0–18.5% ( $\bar{x} = 17.2\%$ ,  $n = 15$ ); HLL/SVL 19.2–24.6% ( $\bar{x} = 21.6\%$ ,  $n = 16$ ); FLL/HLL 71.4–83.3% ( $\bar{x} = 79.0\%$ ,  $n = 15$ ); HL/SVL 16.6–20.9% ( $\bar{x} = 18.7\%$ ,  $n = 16$ ); HW/HL 64.4–81.3% ( $\bar{x} = 72.2\%$ ,  $n = 16$ ); HD/HL 44.5–59.2% ( $\bar{x} = 54.6\%$ ,  $n = 16$ ).

Presacral vertebrae 37–38 ( $\bar{x} = 37.2$ ,  $SD = 0.41$ ,  $n = 6$ ); postsacral vertebrae 32–35 ( $\bar{x} = 33.8$ ,  $SD = 1.26$ ,  $n = 4$ ); phalangeal formula of manus and pes 2.3.4.4.3.

**Allometry.** Due partly to the small sample size, relationships between most of the morphometric characters did not show statistically significant departures from isometry, despite a magnitude and direction of allometry similar to that seen in taxa represented by larger samples. AGL showed significant positive allometry in relation to SVL, while FLL and HL showed significant negative allometry compared to SVL (Table 1). Strong trends were apparent towards positive allometry in TL and negative allometry in HLL with respect to SVL.

**Coloration (in preservative).** Yellow-brown, brown or grey-brown dorsally and laterally, body and tail usually with short broad black spots centrally on many dorsal and lateral scales caudal to axilla, tending to align transversely, especially on tail. Black spots begin at base of scale, and may or (more commonly) may not reach free margin. Nape and head dorsum immaculate or with a few dark flecks or spots. Nape laterally with three large solid or nearly solid black vertical bars, cranialmost lying dorsocaudal to ear, caudalmost above axilla and sometimes dorsally forked. Head laterally with irregular dark margins to some labial scales, particularly the subocular supralabial, and temporal scales. Dark pattern on body and tail absent or almost absent, especially dorsally, on a few of the longer-preserved specimens.

Venter yellow, immaculate on body, throat with (especially laterally) or without dark spots forming weak vermiculations, tail sometimes with a few dark spots extending lateral pattern ventrad. Palms yellow.

**Coloration (in life)** (Fig. 1). Two live individuals from Galena (one AM R134998) were examined. Both had orange red irides, black pupils, slightly blue-grey tinged oral mucosa and dark blue-black tongues. The throat and body and tail venter had orange macules centrally on individual scales, while the non-black spotted lateral and dorsal body and tail scales had an orange flush. In other respects, the coloration was similar to preserved material.

**Distribution.** Lower west coast and hinterland of WA, from the Murchison River at Galena in the north, inland to 56 km south-east of Yalgoo, and south to the Irwin River (Fig. 4).

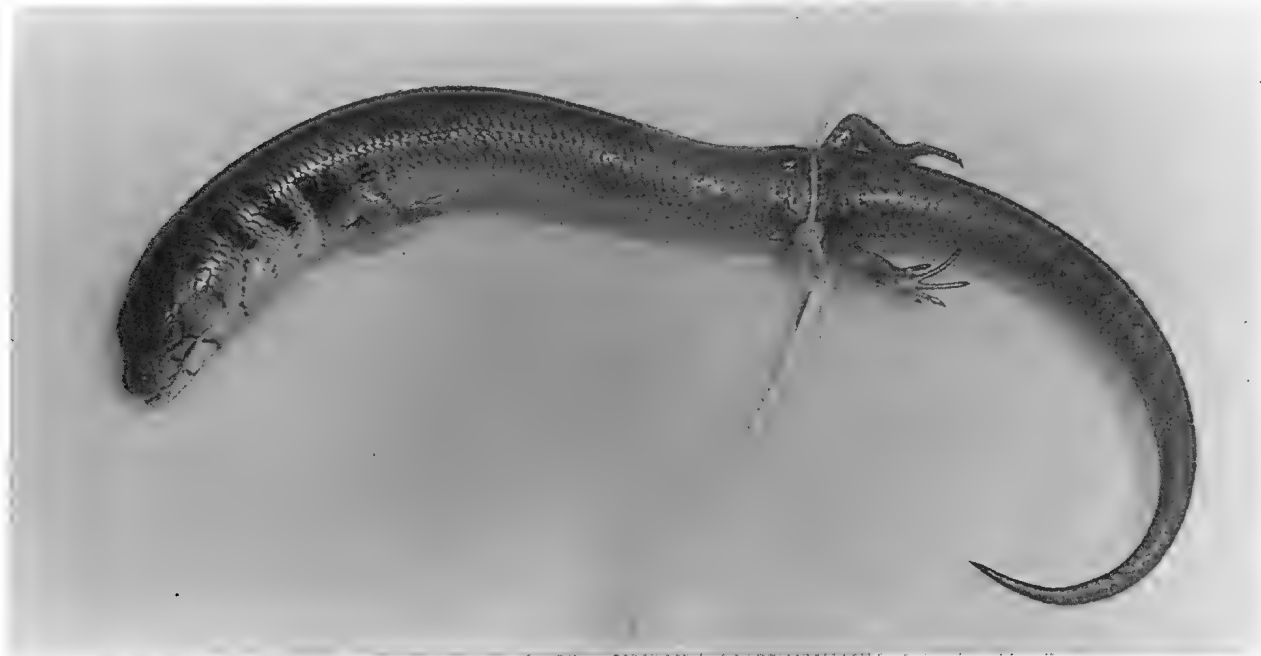


Fig. 2. Lectotype of *Hinulia branchialis* Günther (BMNH 1946.8.19.48).

The early Coolup record (MV D4605; donated H.M. Giles 26.i.1927) is probably in error. While the specimen is typical of *C. branchialis*, the locality is 420 km south of the next nearest record, and is unsupported by more recent collections in this region, which is close to Perth. As the MV collection also includes a specimen of *Egernia napoleonis* (D4192), a species not known from north of the Jurien Bay region, of similar age with locality Champion Bay [= Geraldton], it is assumed that some error in data recording has occurred.

The locality Swan River associated with the NHMW specimens, received in 1870 from the entomologist Boucard, probably represents a shipping point rather than accurate collection data.

**Type material.** *Hinulia branchialis* was described by Günther (1867) from three specimens from Champion Bay, "north-west coast of Australia". The latter is presumed to be a *lapsus* for "Western Australia", as given earlier in Günther's paper (p. 45). The city of Geraldton is now situated on the shores of Champion Bay.

Of the three syntypes (BMNH 1946.8.19.47–49), Wells & Wellington (1985) designate 1946.8.19.48 as lectotype. We have examined all three types, and all are typical of the taxon described here. The lectotype (Figs 2,3) has the following combination of characters: supraciliaries six, postsuboculars two (uppermost of usual three fused with last supraciliary), nuchals 3/2, supralabials seven, infralabials six, upper palpebrals eight, lower palpebrals nine,  $\alpha$ -configuration of secondary temporals, midbody scales 22, paravertebral scales 64, subcaudal scales 64, subdigital lamellae 11, SVL 65 mm, AGL 38.5 mm, TL 55 mm, FLL 12 mm, HLL 15 mm, HL 11.5 mm, HW 8.6 mm, HD 6.4 mm.

**Habitat.** Little is known of the habitat preferences of this taxon. The two Galena specimens (AM R134998, WAM R71052) were taken under tin in *Acacia* scrub on hard red clay soils and "under rock in wash area, below flood level" respectively, while the specimen from near Mingenew (WAM R48638) was found under laterite boulders on top of a limestone ridge in *Acacia* scrub. Two specimens from Galena held in captivity spent most of the daylight hours buried below the surface in gravelly sand and leaf litter.

**Predation.** The easternmost specimen (WAM R89448) was taken, together with another tail of the same species, from the gut of the snake *Pseudechis butleri* (WAM R25815).

**Reproduction.** MCZ 33249 (SVL = 73 mm) collected 20.ix.1931, is a mature male with grossly enlarged turgid testes. Most of the other specimens examined either lack collection dates, or are in poor condition or obviously immature and were not dissected.

**Conservation status.** Despite occurring close to relatively large population centres, very few specimens of this taxon have been collected in recent years. Of the 18 known specimens, 14 were collected prior to 1940, while only four have been collected since 1960. Much of the known range lies in the northern part of the Western Australian wheatbelt, where the natural habitat has been badly degraded by clearing for agriculture and by grazing, and it is probable that this taxon is declining. None of the known localities lie in or close to the few nature reserves in this area.

Cogger *et al.* (1993) used a quantified objective ranking system to categorise the conservation status of

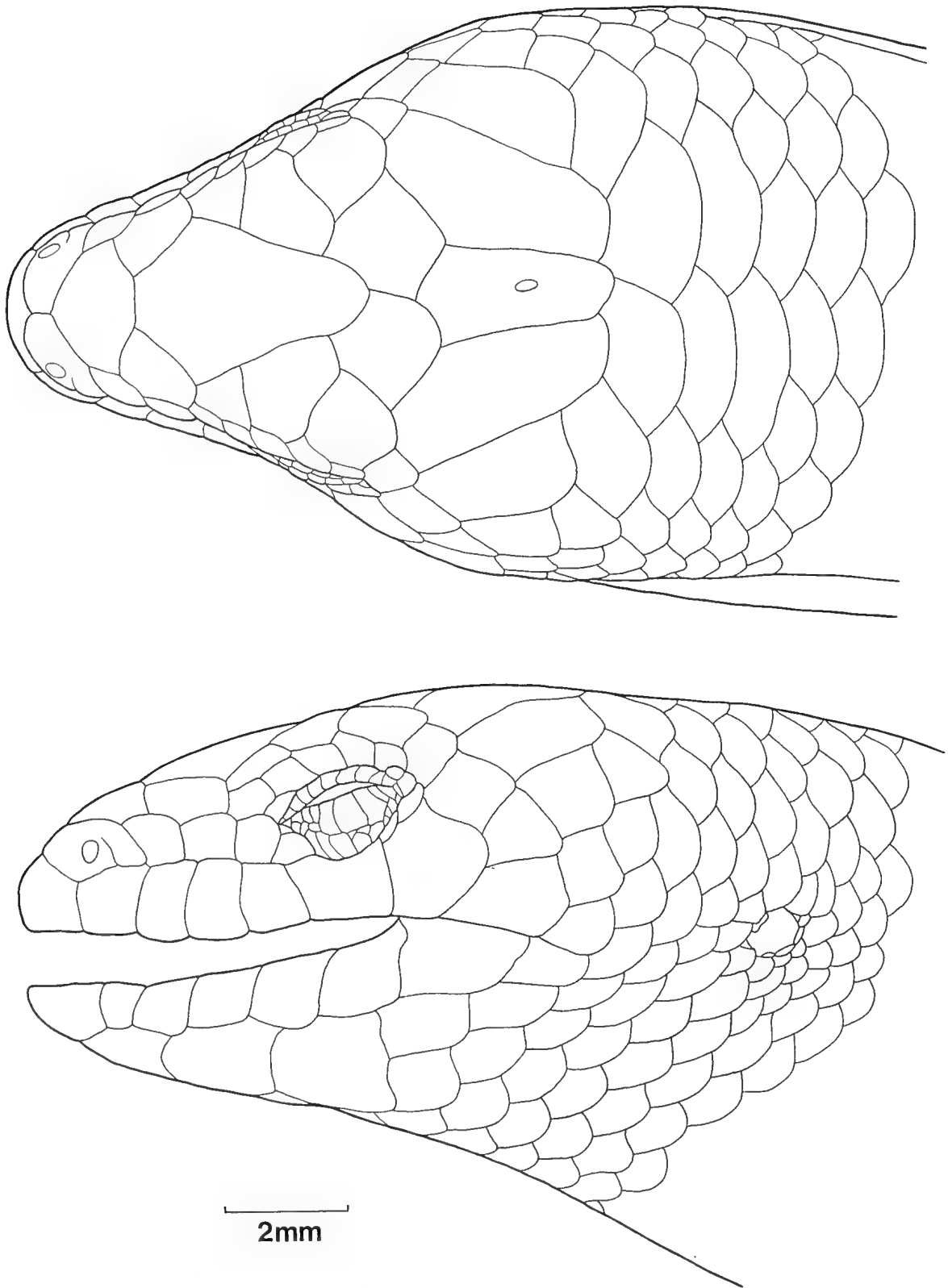


Fig. 3. Head shields of lectotype of *Hinulia branchialis*.

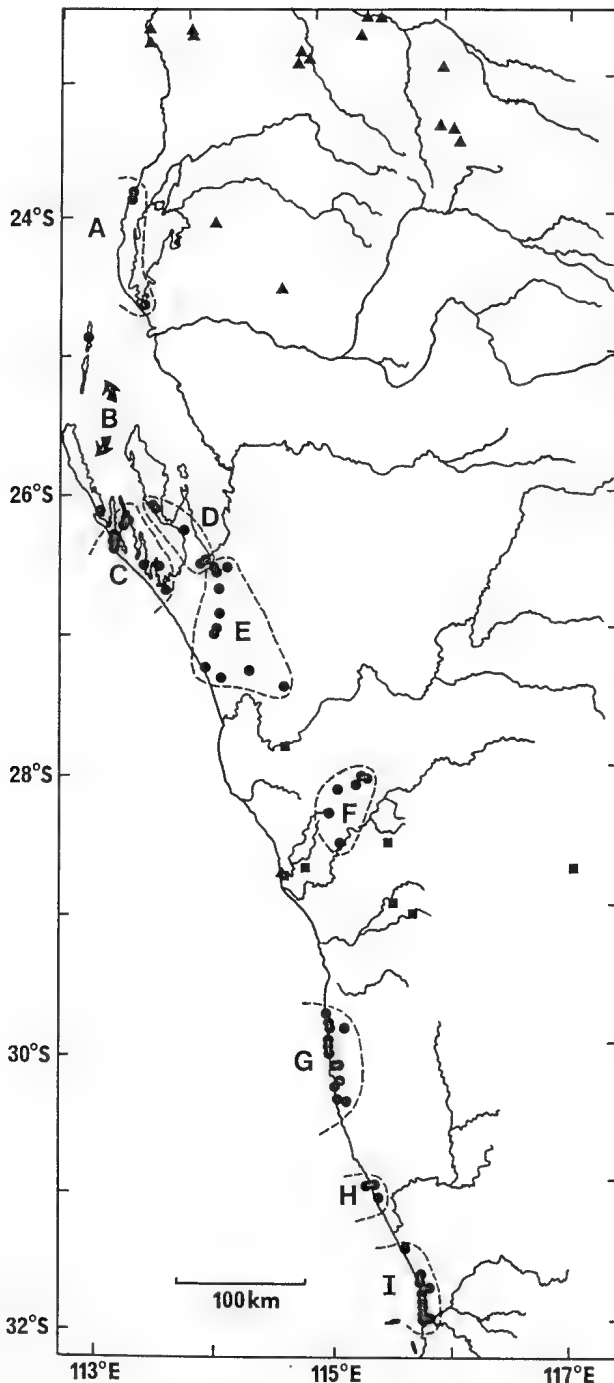


Fig. 4. Distribution of *Cyclodomorphus branchialis* (squares) and *C. celatus* (dots) along lower west coast of Western Australia. Nearest records of *C. m. melanops* are indicated by triangles. Dashed lines and letters indicate populations of *C. celatus* used in describing geographic variation, as follows: A, Gnaraloo; B, Dirk Hartog Island; C, Edel Land; D, Peron Peninsula; E, Zuytdorp; F, Yuna; G, Jurien; H, Lancelin; I, Perth.

Australian reptiles. Using their system, we determine the following score for *C. branchialis*: Biological Variables: 1b, 2b, 3c, 4c, 5d, 6Ab, 6Bc, 7Ab, 7Bb, 7Cc, score 32; Action Variables: 1b, 2a, 3a, 4b, score 30; Supplemental

Variables: 1c, 2b, 3b, 4a, 5d, score 17. Using the criteria adopted by Cogger *et al.* (1993), this species should be considered VULNERABLE.

**Specimens examined** (all localities are in Western Australia): AM R134998, WAM R71052, Galena; BMNH 1946.8.19.47–49, Champion Bay (LECTOTYPE and PARALECTOTYPES); 69.5.25.2–3, WA; MCZ 33247, Nannekine; 33248–49, Mullewa; MV D4605, Coolup (in error); NHMW 10137a–b, Swan River (in error); WAM R1724–25, R1727, Newmarracarra; R48638, 36 km north-north-east Mingenew; R89448, 56 km south-east Yalgoo.

### *Cyclodomorphus celatus* n.sp.

Figs 5–7

**Type material.** HOLOTYPE: WAM R93111, Ledge Point, WA, collected by M. Peterson, G. Shea and B. Coulson on 26.v.1985. PARATYPES: all other specimens listed below as examined.

**Diagnosis.** *Cyclodomorphus celatus* differs from all other members of the *C. branchialis* species group in the combination of a mode of 22 midbody scales, 61–77 paravertebral scales, 61–74 subcaudal scales, interparietal scale  $\frac{3}{4}$  length and breadth of frontal, a small, usually vertically slit-like ear aperture, pale grey to mid grey-brown dorsal ground with black streaks centrally on most dorsal body scales, and three or more series of black streaks arranged in vertical bars on the sides of the neck, but not fused into solid black patches.

**Description.** Parietals completely separated by interparietal (94.6%,  $n = 205$ ), or in point to broad contact caudally (5.4%); interparietal broadest rostrally, approximately  $\frac{3}{4}$  length and breadth of frontal in adults, slightly larger in juveniles; transversely enlarged nuchals 0–5 on each side ( $\bar{x} = 3.1$ ,  $SD = 0.66$ ,  $n = 418$ ), usually three (68.4%); loreals rarely three unilaterally (1.4%,  $n = 210$ ), one unilaterally (2.9%), or one bilaterally (1.4%); supraoculars rarely two unilaterally (1.5%,  $n = 205$ ), or bilaterally (0.5%), or four bilaterally (0.5%), reduction to two due to fusion of first supraocular and first supraciliary ( $n = 1$ ), first and second supraocular ( $n = 2$ ) or second and third supraocular ( $n = 1$ ), increase to four due to division of third supraocular; supraciliaries 3–7 ( $\bar{x} = 6.0$ ,  $SD = 0.38$ ,  $n = 415$ ), usually six (91.6%), first and last largest, third-last usually projecting between second and third supraocular, remainder moderate, subequal; presuboculars rarely three unilaterally (0.5%,  $n = 210$ ), or one unilaterally (1.0%) or bilaterally (1.4%); postsuboculars 2–4 ( $\bar{x} = 3.2$ ,  $SD = 0.43$ ,  $n = 416$ ), usually three (78.4%); upper palpebrals 7–10 ( $\bar{x} = 8.5$ ,  $SD = 0.70$ ,  $n = 191$ ); lower palpebrals 7–12 ( $\bar{x} = 9.1$ ,  $SD = 0.82$ ,  $n = 191$ ); secondary temporals usually in  $\alpha$ -pattern (93.5%,  $n = 418$ ), rarely in  $\beta$ -pattern (6.5%); supralabials 6–8 ( $\bar{x} = 7.0$ ,  $SD = 0.28$ ,  $n = 442$ ), usually seven (92.3%), usually third-last (99.3%) below





Fig. 5. A live *Cyclodomorphus celatus* from Ledge Point, WA (photo: M. Peterson).

centre of eye, separating pre- and postsuboculars, rarely second last, when last two fused; infralabials 5–8 ( $\bar{x}$  = 6.0, SD = 0.35,  $n$  = 418), usually six (88.3%); usually first two (96.0%,  $n$  = 420), rarely first three, infralabials contacting postmental; ear small, approximately half height of eye, very narrow, usually covered rostrally by 1–2 overlapping scales, which may overlay 1–2 small acute lobules, and often with a shallow groove behind.

Body scales in 20–24 ( $\bar{x}$  = 21.8, SD = 0.85,  $n$  = 222), usually 22 (73.4%) or fewer (19.4%), longitudinal rows at midbody; scales in paravertebral rows much broader than adjacent lateral dorsal scales, 61–77 ( $\bar{x}$  = 69.1, SD = 2.69,  $n$  = 210); subcaudal scales 61–74 ( $\bar{x}$  = 66.4, SD = 2.62,  $n$  = 91); lamellae below fourth toe 10–15 ( $\bar{x}$  = 11.9, SD = 1.02,  $n$  = 429), each with a narrow to broad light to mid-brown callus.

SVL 38–121 mm; AGL/SVL 60.8–77.3% ( $\bar{x}$  = 68.3%,  $n$  = 210), TL/SVL 69.2–109.3% ( $\bar{x}$  = 90.1%,  $n$  = 87); FLL/SVL 10.7–21.2% ( $\bar{x}$  = 14.8%,  $n$  = 209), HLL/SVL 14.0–24.7% ( $\bar{x}$  = 19.8%,  $n$  = 207); FLL/HLL 66.7–90.0% ( $\bar{x}$  = 75.0%,  $n$  = 207); HL/SVL 13.1–22.6% ( $\bar{x}$  = 15.9%,  $n$  = 210); HW/HL 60.8–77.3% ( $\bar{x}$  = 68.3%,  $n$  = 210); HD/HL 45.4–65.4% ( $\bar{x}$  = 55.7%,  $n$  = 210).

Presacral vertebrae 40–42 ( $\bar{x}$  = 40.6, SD = 0.63,  $n$  = 29); postsacral vertebrae 36–41 ( $\bar{x}$  = 37.9, SD = 1.19,  $n$  = 13); phalangeal formula of manus and pes 2.3.4.4.3.

**Allometry.** With respect to SVL, both AGL and TL showed positive allometry, while limb lengths and HL

showed negative allometry. With respect to HL, HD showed significant positive allometry, while HW was nearly isometric (Table 2).

**Coloration (in preservative).** Pale grey-white or white to mid grey-brown dorsally and laterally, body and tail usually with longitudinal black streaks (often cream-edged on darker specimens) centrally on most dorsal and dorsolateral body scales caudal to axilla, often forming irregular black stripes on tail. Black streaks extend length of scale, and may be single or paired. Nape with similar but weaker and sparser dark streaks, arranged on side of neck to form 3–4 weak vertical bars, usually one rostral to ear, 2–3 between ear and axilla. Head dorsum with or without black spotting, especially along margins of head shields. Head laterally with irregular dark margins to shields, particularly subocular supralabial.

Venter cream, with or without dark spots on chin and throat, forming weak vermiculations, and with or without fine dark flecks on body and tail. Palms cream with greyish to light brown calli.

Juveniles often with dorsal and ventral ground more yellow-brown or red-brown, reduced dark streaks, dark grey head and white centres to dorsal and lateral scales. Dorsal ground extends ventrolaterally in bars on side of neck, equivalent to dark bars of adults.

**Coloration (in life)** (Fig. 5). Two small individuals (AM R88482–83, SVL 62–65 mm) had pale straw yellow



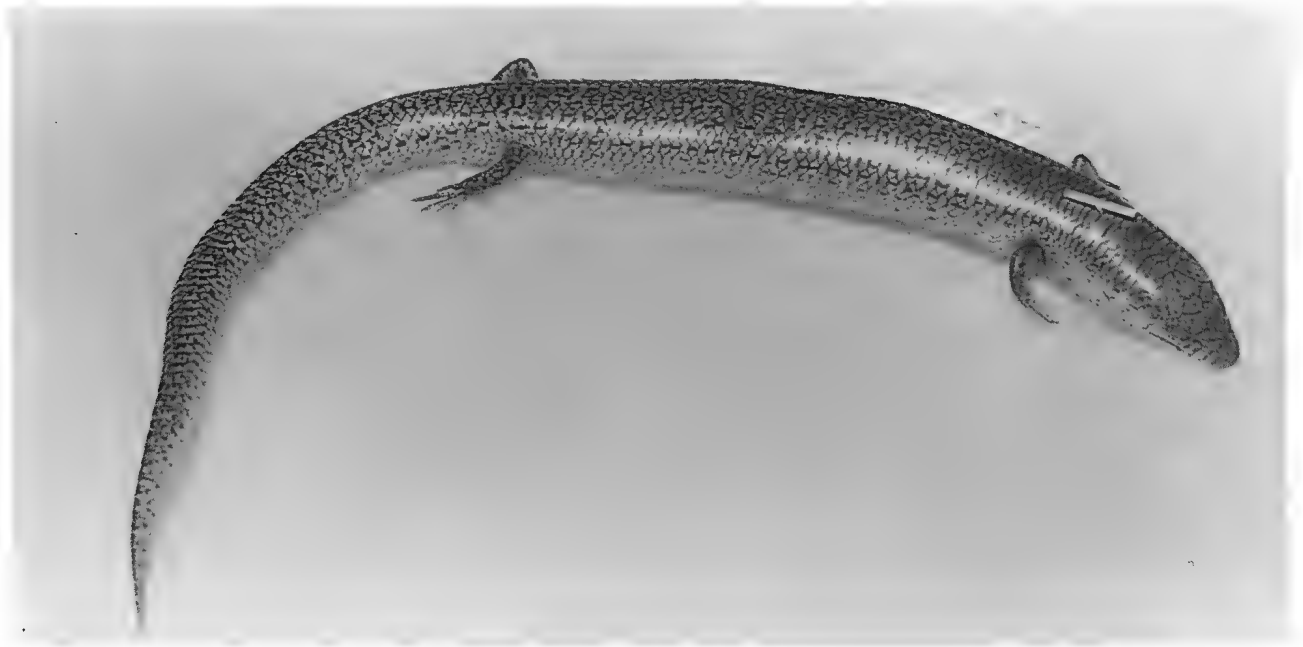


Fig. 6. Holotype of *Cyclodomorphus celatus* (WAM R93111).

venters, while a larger individual from the same locality showed little or no trace of such coloration. A fourth individual from a nearby location had venter and cranial flanks pale peach. The iris of the first three specimens was noted as pale coppery yellow, while that of the fourth was noted as coppery red. The iris in AM R102669–75 was described as a rich dark copper colour (A.E. Greer, pers. comm.).

The iris in five other specimens we examined was coppery-red.

**Details of holotype.** The holotype (Figs 6,7) has the following character states: supraciliaries 6/5; postsuboculars three; nuchals 4/3; supralabials seven; infralabials six; upper palpebrals eight; lower palpebrals nine;  $\alpha$ -configuration of secondary temporals; midbody scales 22; paravertebral scales 69; subcaudal scales 64; subdigital lamellae 13; SVL 93 mm, AGL 59 mm; TL 88 mm; FLL 14 mm; HLL 18.5 mm; HL 14.8 mm; HW 9.4 mm; HD 5.4 mm.

**Sexual dimorphism.** Mature males were slightly smaller (82–115 mm,  $\bar{x}$  = 96.4 mm, SD = 7.88,  $n$  = 56) than mature females (SVL 84–121 mm,  $\bar{x}$  = 100.3 mm, SD = 8.19,  $n$  = 44; Mann-Whitney U test,  $z$  = 2.36\*). In general, males had longer tails, limbs and heads, but shorter bodies than females (Table 3), although head shape was not sexually dimorphic. While some of this variation was probably due to the effect of the shorter body of males on SVL, used as the measure of overall size in all comparisons, it was not solely an artifact of this effect. For example, HLL in males was much greater than in females, even at maximum size (42.9% [ $n$  = 63] of males had HLL  $\geq 20$  mm, and up to 23 mm, while only one of 50 females had HLL even reaching 20 mm).

Overall, males additionally had slightly more

numerous subdigital lamellae below the fourth toe (10–14,  $\bar{x}$  = 12.1, SD = 0.96,  $n$  = 118 vs 10–15,  $\bar{x}$  = 11.7, SD = 1.03,  $n$  = 93,  $t_{210}$  = 2.88\*\*) than females, although the difference was not significant within the populations examined.

No significant differences were detected between males and females in mean number of midbody scales, paravertebral scales, subcaudal scales, supralabials, infralabials, postsuboculars, supraciliaries, nuchals, upper palpebrals or lower palpebrals.

**Distribution.** Coastally and near-coastally along the lower west coast of WA, from “Gnaraloo” south to the north bank of the Swan River, including Bernier, Dirk Hartog, Baudin and Lancelin Islands, and inland as far as the Yuna district (Fig. 4). There is only a single unconfirmed record (WAM R31545, presumably near Geraldton, collected by a local resident) from the coastal strip and hinterland between “Gie Gie” Outcamp, north of the Murchison River, and Beagle Point, and it is possible that there is some geographic disjunction in this area between the northern and southern parts of the range. The population in the Yuna district is probably isolated from the coastal populations, as is the Gnaraloo population with respect to the Shark Bay mainland populations, with unsuitable hard soils in much of the intervening area in both cases.

Records from Albany (SAM R26128–30) are almost certainly in error. Albany is 440 km south-east of the nearest records, and on the southern rather than the western coast.

Storr, Smith & Johnstone (1981) illustrate an individual of *C. celatus* from Dorre Island. We have been unable to locate any specimen from this locality in the WAM collection to verify this record.

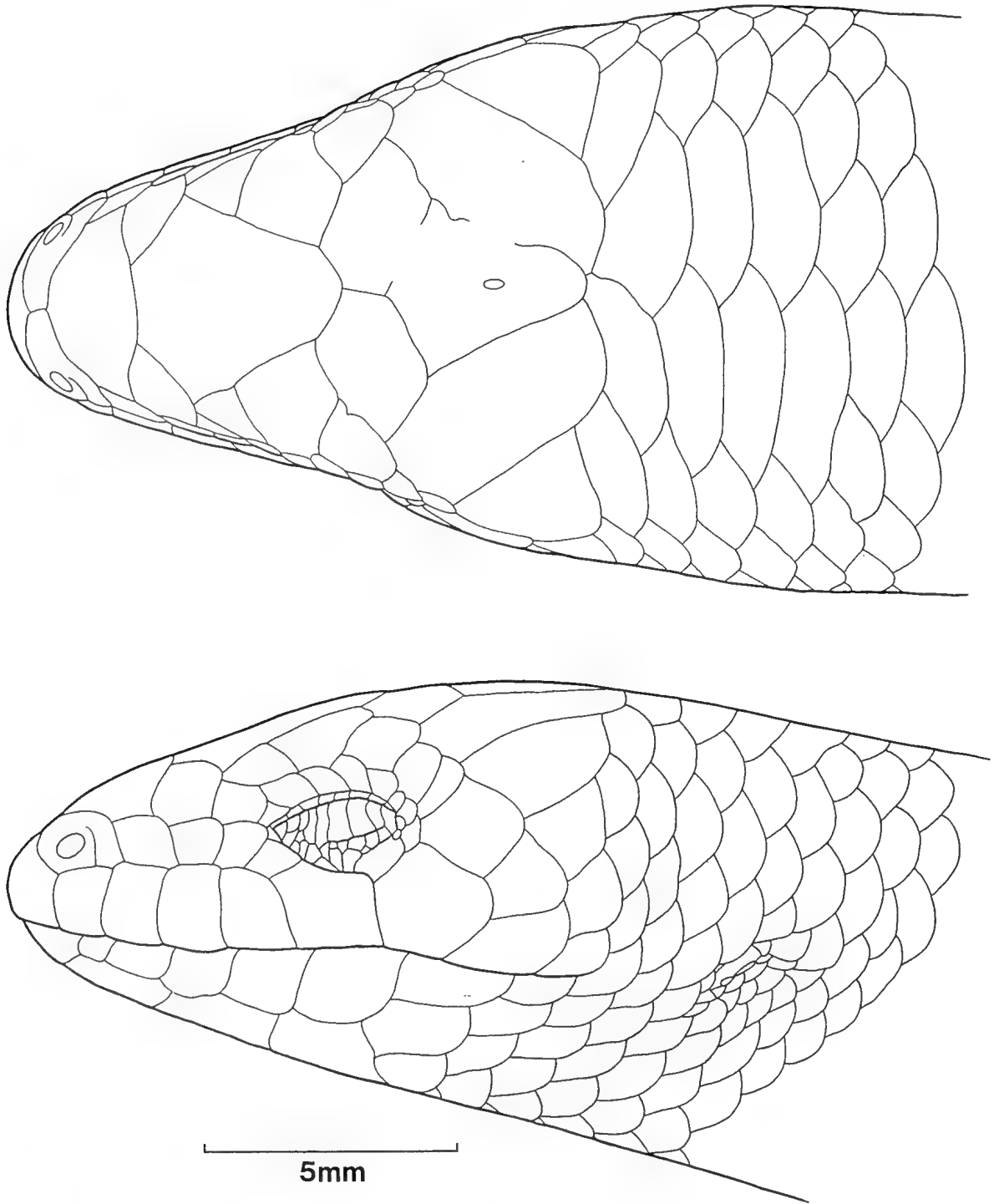


Fig. 7. Head shields of holotype of *Cyclodomorphus celatus*.

**Geographic variation.** For the purposes of describing geographic variation, the overall distribution of *C. celatus* was divided into nine subunits, named, from north to south, Gnaraloo, Dirk Hartog Island, Edel Land, Peron Peninsula, Zuytdorp, Yuna, Jurien, Lancelin and Perth (Fig. 4). Samples from Bernier Island ( $n = 1$ ), Baudin Island ( $n = 1$ ) and Lancelin Island ( $n = 11$ ) were included in the Dirk Hartog Island, Edel Land and

Lancelin populations, respectively. Analysis of variance did not reveal significant variation in mean number of supraciliaries, nuchals or upper palpebrals. Statistically significant variation in other scalational characters was relatively minor, and showed no consistent pattern.

Paravertebral scales. ANOVA:  $F_{8,198} = 3.548^{***}$ . Population means ranged from 66.4 (Gnaraloo) to 70.6 (Peron Peninsula), with only the Gnaraloo value below

68.6, and showing significant differences with other populations (Peron Peninsula, Yuna, Lancelin, all with means above 70.3).

Midbody scales. ANOVA:  $F_{8,210} = 3.574^{***}$ . Means ranged from 21.4 (Jurien) to 22.1 (Peron Peninsula, Lancelin, Perth). Only Jurien had a significantly different mean to other populations (Lancelin, Yuna, Perth), although the mode in each case was 22. Only in the two southern populations were counts of 24 seen more than once.

Subcaudal scales. ANOVA:  $F_{8,80} = 8.692^{***}$ . Means ranged from 63.3 (Perth) to 69.8 (Peron Peninsula), with only the latter population, Zuytdorp ( $\bar{x} = 68.6$ ) and Edel Land ( $\bar{x} = 67.9$ ), all northern mainland populations, having means above 66.5. Significant differences were detected between these three populations and several populations with low means (all were different to Perth, Lancelin and Dirk Hartog ( $\bar{x} = 64.3$  for latter two), Peron Peninsula also different to Jurien ( $\bar{x} = 66.1$ ) and Yuna ( $\bar{x} = 66.2$ )).

Subdigital lamellae. ANOVA:  $F_{8,412} = 7.065^{***}$ . Means ranged from 11.4 (Perth) to 12.7 (Lancelin), with only the former less than 11.6 and only the latter greater than 12.1. Only these two extreme values showed significant differences to other populations, with the Lancelin mean significantly greater than all other means, and the Perth mean significantly lower than Lancelin, Edel Land ( $\bar{x} = 12.1$ ) and Jurien ( $\bar{x} = 12.0$ ).

Supralabials. ANOVA:  $F_{8,429} = 4.360^{***}$ . Means ranged from 6.9 (Lancelin) to 7.2 (Gnaraloo), with significant differences only between these two extremes, and between Gnaraloo and Jurien ( $\bar{x} = 7.0$ ).

Infralabials. ANOVA:  $F_{8,405} = 2.581^{**}$ . Means ranged from 5.8 (Lancelin) to 6.2 (Zuytdorp), with significant differences only between these two extremes, and Lancelin and Yuna ( $\bar{x} = 6.1$ ).

Postsuboculars. ANOVA:  $F_{8,403} = 8.640^{***}$ . Means ranged from 3.0 (Edel Land) to 3.8 (Gnaraloo), with only the latter population and Peron Peninsula ( $\bar{x} = 3.6$ ) having means above 3.4, and modes of four. These two populations had means significantly greater than Edel Land, Zuytdorp, Yuna, and all populations further south (all with  $\bar{x}$  in the range 3.0–3.1).

Lower palpebrals. ANOVA:  $F_{8,180} = 2.203^*$ . Means ranged from 8.8 (Edel Land) to 9.6 (Perth). The only significant difference was between these two extreme values.

Coloration. There was marked geographic variation in coloration, with an apparent correlation with substrate colour, animals from darker substrates (red to brown sands) being more grey-brown dorsally, while animals from white sands had a paler dorsum (see also habitat account).

Specimens from "Gnaraloo", Dirk Hartog Island, and some Edel Land material had a darker dorsal ground and broader cream-edged dark streaks, giving a darker and very mottled appearance. Dirk Hartog Island juveniles had similar coloration to adults. Peron Peninsula material (both adults and juveniles) had a more grey-brown dorsum and weaker dark streaks. Adults from Edel Land

and the Zuytdorp coastline had little or no flecking on the head dorsum, grey-brown body dorsum and vertical bars on the side of the neck usually strongly developed, but occasionally absent. Edel Land juveniles (fig. 4, pl. 19 in Storr, Smith & Johnstone, 1981) were mid red-brown above with a prominent white spot caudally and fine black peppering on the caudal half of each dorsal body scale. Head and face were dark grey, unmarked, lips cream with dark margins to labial scales. The venter was cream-yellow with white centres to many scales.

Material from the vicinity of Yuna was grey to brown dorsally, usually with very reduced dark streaking on body dorsum, and head, nape and throat unmarked. The dark flecks were slightly more prominent laterally. Juveniles of this population resembled *C. melanops* juveniles, being mid-brown above, with no dark flecks, but a white spot on each body scale. They differed, however, in their dark grey heads and bars of dorsal ground laterally on neck.

Southern populations (Jurien and Lancelin) were very pale, with white to grey-white dorsal ground, but narrow black dorsal and lateral streaks still prominent, while Perth adults were light grey above with very weak dark streaks. Juveniles were yellowish to red-brown above with darker grey-brown head, white spots on body and tail scales, vertical bars on sides of neck weak, and usually with dark streaks dorsally and laterally.

**Comparison with other taxa.** *Cyclodomorphus celatus* is geographically very close to *C. branchialis*, almost surrounding it. However, the two taxa remain allopatric. Although there are records of both from the Geraldton/Champion Bay area, it is likely that these records are imprecise. The Champion Bay records of *C. branchialis* (the type series) date from the 1860's, the specimens being presented to the BMNH collection by the entomologist F.H. Duboulay. Although Duboulay lived in the Champion Bay district at the time, he and his brother lived on "Minnannooka" Station, away from the coast (Musgrave, 1932), and on the harder soils characteristic of more recent localities for the taxon. The accuracy of the Geraldton record of *C. celatus* is discussed above, under Distribution. Leaving aside these records, the nearest approaches of the two taxa are 46 km, between the Murchison River at Galena and 46 km to the north, and approximately 35 km, between Mullewa and East Yuna Reserve. The specimens of each species from these localities are typical and show no signs of introgression.

*Cyclodomorphus celatus* may be readily differentiated from *C. branchialis* by the lack of solid dark "gill" markings on the neck (although there are vertically aligned series of dark longitudinal streaks in corresponding positions), and by having usually the  $\alpha$ -configuration of temporals (vs  $\beta$ -), a mode of 22 midbody scales (vs 24), and a much longer body and tail. The more elongate body of *C. celatus* may be seen in morphometrics (AGL/SVL and TL/SVL; Tables 1,2), scalation (paravertebral scales  $\bar{x} = 69.1$  vs 65.2; subcaudal scales  $\bar{x} = 66.4$  vs 60.4) and osteology

(presacral vertebrae 40–42 vs 37–38; postsacral vertebrae 36–41 vs 32–35). Additionally, the ear of *C. celatus*, while small as in *C. branchialis*, has the rostral edge covered by overlapping scales, which cover any lobules along this margin. This feature is an autapomorphy of the species.

**Etymology.** The specific epithet is derived from the Latin verb *celare*, to conceal or hide, and alludes to the small, partially covered ear, the propensity for this species (and some other members of the species group) to shelter in loose sand, and the failure of previous authors to recognise the differentiation between this species and *C. branchialis*.

**Habitat.** Storr (1976) suggested that *C. celatus* (as *Orolepida branchialis*) was largely confined to coastal limestones, while *C. melanops* was a *Triodia* inhabitant, and it was partly on the presence of a *celatus*-like *Triodia*-inhabiting population from Yuna that he refrained from recognising the two as distinct. However, the many observations on microhabitat usage accumulated since then (partly summarised in the herpetofaunal survey reports of Storr & Harold, 1978, 1980, 1984 and Storr *et al.*, 1983) indicate that *C. celatus* inhabits a wide range of vegetation and soil types, and shows distinct geographic trends in microhabitat preferences.

The WAM specimens of the northernmost population (Gnaraloo) were taken in *Acacia* litter in *Acacia coriacea* shrubland on pinkish sand. Specimens from other northern populations, including Bernier Island ( $n = 1$ ), Peron Peninsula ( $n = 7$ ) and the southern part of Edel Land ( $n = 4$ ) and adjoining Zuytdorp region ( $n = 4$ ) have been taken from *Triodia* and *Plectrachne* clumps. The Dirk Hartog Island population may also inhabit hummock grasses, specimens being taken from "*Acacia ligulata*" scrub, scattered *Plectrachne*, on white-pink sand" (WAM R57085–86) and "low shrubland of *Acacia*, *Diplolaena*, *Triodia* and *Thryptomene*" (WAM R60875), although other specimens for which specific data are available were taken "under tin on samphire flat" (WAM R59706) and pit-trapped in an area of open sparse ground cover. Populations inhabiting hummock grasslands may also utilise other microhabitats, AM R101805–06 being taken from under litter mats below low trees in shrubland/low scrub with a *Triodia* understory. Substrate types for such hummock grass-inhabiting populations on the mainland include light brown soil, red to yellow-red sands, and brown to red-brown loamy sandplains.

Other non-coastal northern specimens have been taken in a variety of shrub and scrub habitats, including in litter in "mallee on yellow sand" (WAM R59005) and "*Banksia* shrubland on yellowish sand" (WAM R64408), in spoil in "*Hakea* shrubland on reddish soil" (WAM R64409, R64413) and "low, moderately dense *Banksia* shrubs/heath on yellowish sand" (WAM R64338) and "under tin in open *Acacia* on reddish-brown sand" (WAM R54536–40).

In contrast, coastal populations in Edel Land and along the Zuytdorp coastline inhabit a distinctly different set of habitats and microhabitats, mainly limestone slabs and exfoliations ( $n = 5$ ) and coastal grasses (especially *Spinifex longifolius*) on white sand dunes ( $n = 3$ ), other specimens being taken under tin (AM R102661), "within pile of sticks" (WAM R54747–48, R54759) and from a claypan surrounded by *Acacia* on gently rolling grey sandy soil hills (AM R101975–77, R102715–16, R102728–30). One specimen (WAM R66376) was taken from a habitat combining the coastal and inland features ("burnt from *Spinifex longifolius* in shrubland on red-brown sandplain").

The Yuna population, like other northern inland populations, usually inhabits *Triodia* and *Plectrachne* (Storr, 1976; Burbidge *et al.*, 1978; WAM R57514, AM R105626). However, Dell & Chapman (1981) record three specimens from East Yuna Reserve, "one under *Plectrachne danthonioides* ... [WAM R48271]; 1 under roadside spoil in mallee ... [WAM R48102]; 1 active in daytime in shrubland ... near top of breakaway where there were surface sandstone fragments [WAM R56995]", suggesting that the population is not restricted to hummock grasses.

The three southern populations (Jurien, Lancelin and Perth), like the Edel Land population in the north, are largely confined to coastal and near-coastal white sand dunes and sandplains.

About Jurien, most specimens were taken under rubbish, tin, boards, etc. ( $n = 4$ ) in low coastal heath on white sand dunes ( $n = 23$ ), although several specimens have been taken on or at the edge of salt/samphire flats (Dell & Chapman, 1977;  $n = 6$ ), two of these (WAM R49059–60) found under fallen bark below *Casuarina obesa*. WAM R72986–87 were taken in "*Acacia* scrub behind coastal dunes", while WAM R72907–08 were dug from beneath loose soil in *Banksia* heath. One specimen (WAM R71942) was found crossing a track at 1030hrs in *Acacia/Melaleuca* heath on sandy soil. A few specimens ( $n = 5$ ) were found under limestone or concrete slabs.

The Lancelin and Lancelin Island populations appear to mostly shelter beneath limestone slabs (Ford, 1963;  $n = 9$ ). AM R102665–68 and R102685 were found under loosely consolidated sand slabs on white sand hillocks with scattered shrubs over grass.

Most specimens from the coast north of Perth were taken in heath on consolidated coastal dunes, although one (WAM R83075) was taken from an *Acacia* thicket on grey sand. Most were taken under rubbish ( $n = 5$ ), although one (WAM R59318) was taken under a sedge clump. Sorrento specimens were taken from "under scrub on limestone" (WAM R51159) and "under dead log in *Banksia* scrub" (WAM R53710–11), while two Wanneroo specimens (WAM R78472–73) were taken in "*Banksia*, tuart woodland with occasional jarrah; limestone pinnacles", and one (WAM R61750) from Mullaloo from "under limestone rock in garden".

Captive specimens we have observed have readily burrowed in loose sand, and spend their inactive periods below the surface.

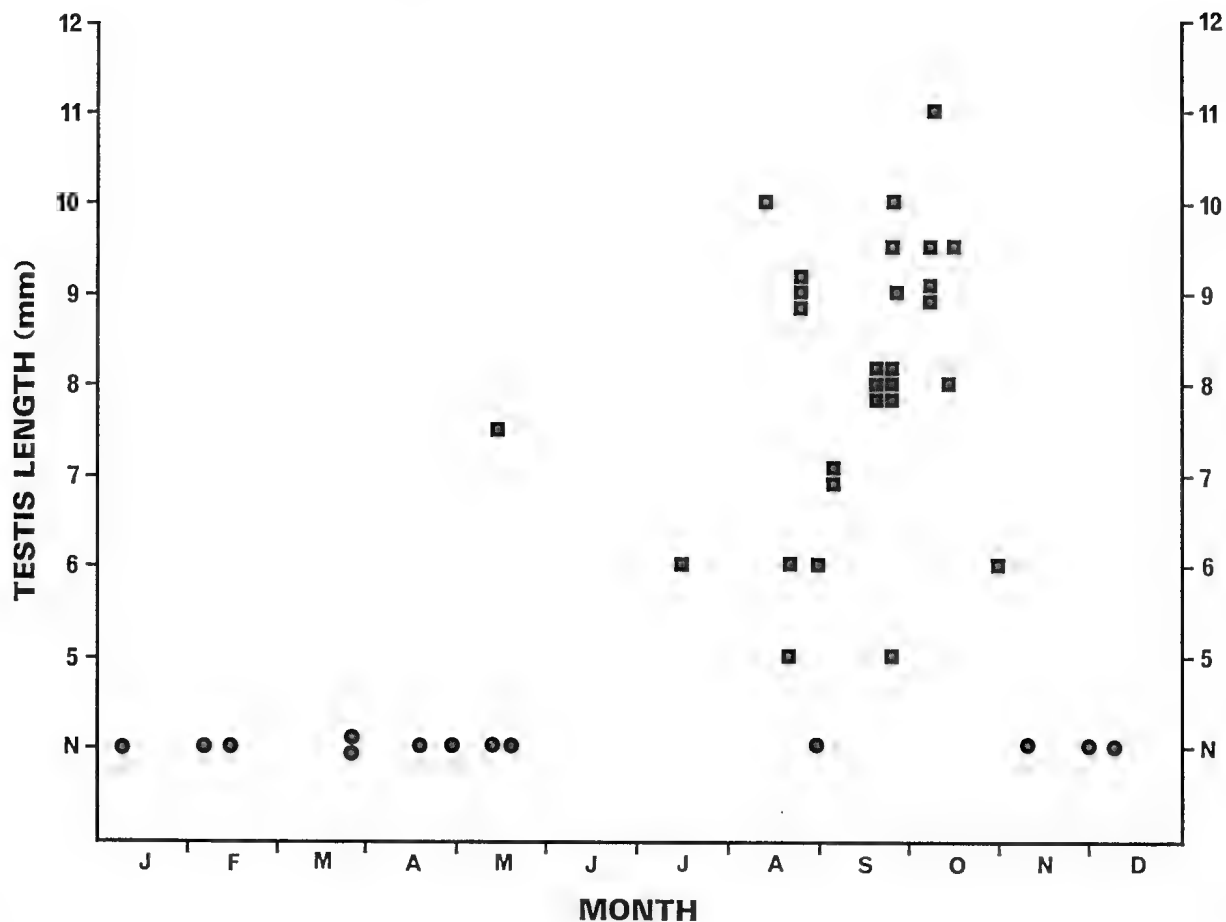


Fig. 8. Seasonal variation in length of turgid testes, and the occurrence of flaccid testes in *Cyclodomorphus celatus*. N represents small testes less than 5 mm long and assumed to be non-spermatogenic.

**Reproduction.** Male reproductive cycles in *C. celatus* are strongly seasonal (Fig. 8). Enlarged turgid testes  $\geq 5.0$  mm in length were present in most mature-sized males collected between 15 July and 31 October, while testes of mature-sized males collected outside that period were mostly small and flattened.

Female reproductive cycles are similarly seasonal (Fig. 9). None of the mature-sized females (SVL  $\geq 84$  mm,  $n = 15$ ) collected between March and 9 September were gravid, although some August and September females had noticeably larger ovarian follicles than autumn females. Enlarged yolking ovarian follicles were present between 26 September and 18 November, with a single record for 2 January, while unshelled oviducal eggs or developing embryos were present between 22 October and 31 December. One litter from a wild-caught gravid female was born between 11–12 January.

We conclude from the above data that spermatogenic activity reaches a peak in October, coinciding with mating and fertilisation, and young are born in January, following approximately 3 months gestation.

Only four of 26 mature-sized females collected between 26 September and 2 January were not gravid, suggesting that breeding generally occurs annually.

Gravid females carried 3–5 ( $\bar{x} = 3.8$ , mode = 4 (57%),  $n = 21$ ) enlarged yolking ovarian follicles, unshelled oviducal eggs or fully developed embryos. Litter size was not significantly related to maternal SVL ( $r = 0.2304$ ,  $P = 0.315$ ).

**Growth rates:** Seasonal distribution of body sizes in the material examined (Fig. 10) indicates a clear year 1 cohort, and suggests that a SVL of about 82–84 mm (size at maturity) is reached in the second or third year.

**Sex ratio.** The sex ratio of mature-sized material examined is 56 males : 44 females, a ratio not significantly different from 1:1 ( $\chi^2_1 = 1.21$ , n.s.). However, the sex ratio of the September sample (13 males : 2 females) is significantly different from 1:1 ( $\chi^2_1 = 6.67^{**}$ ). Sex ratios of other monthly samples are not significantly different from 1:1, and when the September sample is removed, the overall sex ratio is 43:42, a ratio very close to 1:1. The increased proportion of males in the September sample may reflect an increase in male mobility just prior to the mating season.

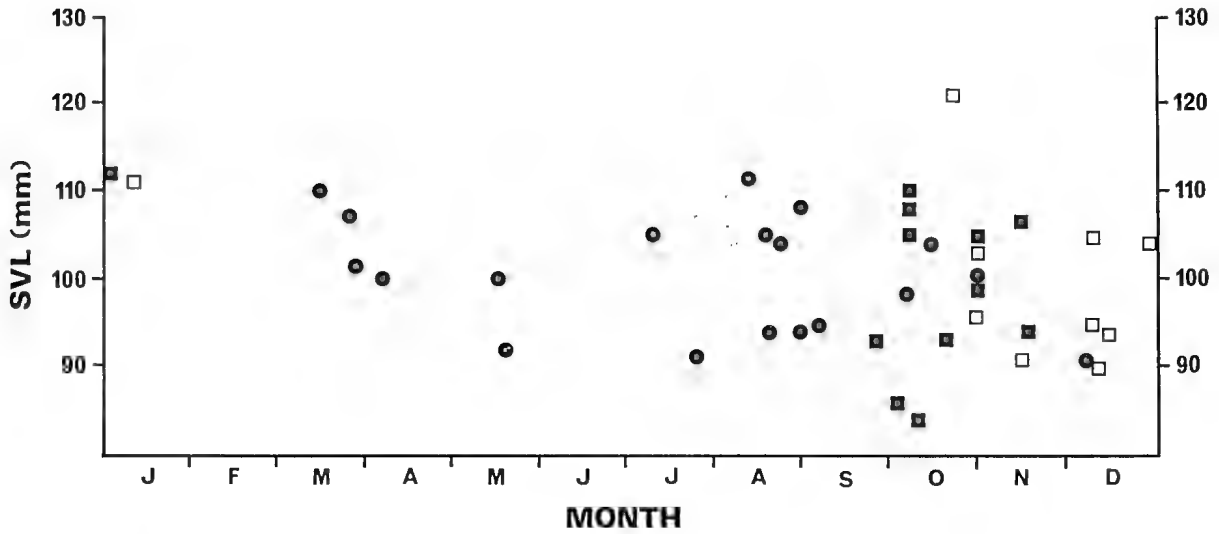


Fig. 9. Seasonal occurrence of non-vitellogenic follicles (dots), yolking ovarian follicles (squares) and oviducal embryos (open squares) in *Cyclodomorphus celatus*.

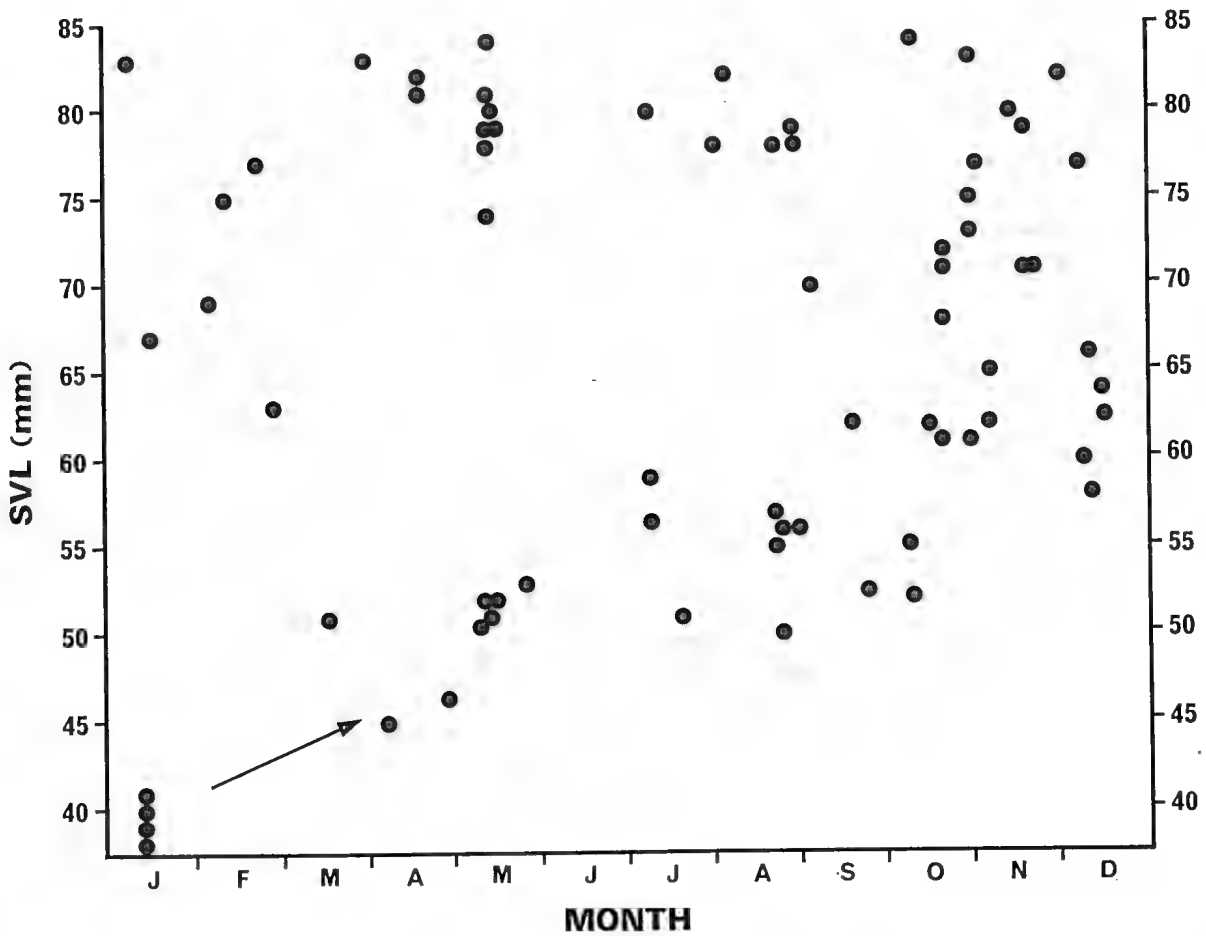


Fig. 10. Seasonal variation in SVL of immature *Cyclodomorphus celatus*. Arrow indicates inferred growth of first year cohort.

**Diet.** Gut contents of specimens we have examined have been largely arthropods. One specimen (WAM R47540) had eaten a skink, *Menetia surda*.

**Specimens examined** (all localities are in WA). **GNARALOO:** AM R134357–59, 3.0 km north “Gnaraloo” HS via Gnaraloo Bay track; WAM R76762, 1 km south “Gnaraloo”; R76888–89, 0.5 km south “Gnaraloo”; R88644, 13 km west-north-west “Boolathana”. **BERNIER ISLAND:** WAM R20497. **DIRK HARTOG ISLAND:** WAM R42371–73, R59706, R60875; R57085–86, 3 km north Cape Ransonnet; R70812–13, 4.3 km 352° Cape Ransonnet. **EDEL LAND:** AM R101975–77, R102715–16, R102728–34, “Tamala” tip; AM R102661, north-east side False Entrance; WAM R25735, Baudin Island, Freycinet Estuary; R39029, R54747–48, R54759, R91707, False Entrance Well, “Carrarang”; R54536–40, 1 km south “Tamala”; R54608–09, R54612, 10 km north-west Useless Loop; R54720, Editarra Well, “Carrarang”; R54774, 3 km south False Entrance Well, “Carrarang”; R55080, 3 km south-west False Entrance Well, “Carrarang”; R55109–12, 4 km south Useless Loop; R58793, 3 km south Sandhill Well; R64560, Zuytdorp Point; R92856, 17 km south-south-east “Nilemah” Outstation; R93921, R93923, 7 km south “Nilemah” Outstation. **PERON PENINSULA:** AM R101805–06, 5.6 km west Denham–Overlander Roadhouse road via Useless Loop road; R105735, 28.3 km north “Nanga” turnoff on Denham road; SAM R29378, 24 km south Denham; WAM R54489–90, R54610–11, 25 km south Denham; R55081, 8 km south-east “Nanga”; R64408, 48 km west Overlander Roadhouse; R81780, 26 km south-south-east Denham. **ZUYTDORP:** WAM R34040, “Gie Gie” Outcamp, 21 miles north-north-west “Murchison House”; R59005, 46 km north Murchison River on North-West Coastal Hwy; R64338, 51 km north-north-west Kalbarri; R64409, R64413, 31 km south-west “Nerren Nerren”; R66360–61, 23 km 237° “Cooloomia”; R66374–75, 17 km 240° “Cooloomia”; R66376, 15 km 302° “Cooloomia”; R88645, 20 km west-south-west “Cooloomia”; R91659, 16 km west “Coburn”; R92671, R92844, R92850, 17 km south-south-west “Hamelin”; R92494–95, 15 km south “Hamelin”. **YUNA:** AM R105626, 23.7 km north-north-east by road of Yuna; WAM R26496, 20 miles north-east Yuna; R47522–45, R56995, Yuna Flora & Fauna Reserve; R47700, Yuna; R48102, R48271, R49922–23, East Yuna Reserve, 30 km south-south-east Yuna; R57514, 40 km north-east Yuna. **JURIEN:** AM R102669–75, R105621, old Jurien tip, 0.5 km east Jurien; ANWC R3149, Leeman; WAM R13413, Stockyard Gully, Jurien Bay; R15859, mouth of Hill River; R19757–59, Beagle Point, 40 miles south Dongara; R30480, 5 miles north-east Jurien Bay; R30494–96, 2.5 miles east Jurien Bay; R31545, presumably Geraldton; R37719, R47803–06, R59658–59, R67337–38, R73104, Green Head; R46576, c. 7 km east Jurien; R48448–51, 5 km west “Padbury”; R48804, nr “Padbury”; R49059–60, R56071, R56094, 5 km east Green Head; R57596, Jurien Bay; R59656–57, 10 km north Green Head; R71942, 5 km north Coolimba; R72907–08, 16 km east Coolimba; R72974, 10 km north Coolimba; R72978–79, 15 km east Coolimba; R72986–87, 8 km south Leeman; R73109, 9 km south Leeman; R73118, Coolimba; R93147, 11 km north-north-east Cervantes. **LANCELIN:** AM R102665–68, R102685, south-east outskirts of Lancelin; SAM R13047a–b, Moore River, 56 miles north Perth; WAM R16544–48, R17878–79, R52102–05, R93715, Lancelin Island; R16549–50, Lancelin; R93109, 5 km south Lancelin; R93110–11, Ledge Point. **PERTH:** AM R47486–89, WAM R10664, R12645, City Beach; AM R88482–83, east of West Coastal Hwy and south of Whitfords Ave, nr junction; MV D9800, WAM R416, R444, Perth; SAM R22872–73,

WAM R59318, Burns Beach; SAM R29420, Scarborough Beach; WAM R4783, R21272, North Beach; R11002, One Tree Hill, betw. Wanneroo & Yanchep; R12914, Dalkeith; R41784, R78472–73, Wanneroo; R46130, Marmion; R48160–61, Scarborough; R50129, R51159, R53710–11, Sorrento; R61750, Mullaloo; R73728, Swanbourne; R83074, 3 km north Burns Beach; R83075, 4 km north-north-east Burns Beach; R83083, 3 km north-north-east Burns Beach; R83871, Two Rocks; R90506, Bold Park. **ERRONEOUS LOCALITIES:** SAM R26128–30, Albany.

### *Cyclodomorphus maximus* (Storr, 1976)

Figs 11–13

*Omolepida maxima* Storr, 1976: 169.

**Diagnosis.** *Cyclodomorphus maximus* differs from all other members of the *C. branchialis* species group in the combination of a mode of 22 mid body scales, interparietal scale  $\frac{1}{2}$ – $\frac{2}{3}$  length and  $\frac{1}{3}$ – $\frac{1}{2}$  breadth of frontal, red-brown dorsal ground with white bars on most dorsal body scales, and large size (maximum known SVL 231 mm).

**Description.** Parietals separated by interparietal (50.0%,  $n = 18$ ) or in narrow to moderate contact caudally (50.0%); interparietal broadest rostrally, approximately  $\frac{1}{2}$ – $\frac{2}{3}$  length and  $\frac{1}{3}$ – $\frac{1}{2}$  width of frontal in adults (slightly larger in juveniles); transversely enlarged nuchals 2–4 on each side ( $\bar{x} = 3.5$ ,  $SD = 0.56$ ,  $n = 38$ ), usually four (58.3%); loreals rarely one unilaterally (10.5%,  $n = 19$ ), due to fusion of the two loreals; supraciliaries 5–7 ( $\bar{x} = 6.2$ ,  $SD = 0.45$ ,  $n = 36$ ), usually six (77.8%), first and last largest, third-last usually flat-topped or projecting slightly between second and third supraocular, remainder moderate, subequal; presuboculars rarely one unilaterally (5.6%,  $n = 18$ ); postsuboculars 3–5 ( $\bar{x} = 4.1$ ,  $SD = 0.55$ ,  $n = 34$ ), usually four (70.6%); upper palpebrals 9–12 ( $\bar{x} = 10.3$ ,  $SD = 0.70$ ,  $n = 16$ ); lower palpebrals 10–13 ( $\bar{x} = 11.0$ ,  $SD = 0.97$ ,  $n = 16$ ); secondary temporals in  $\alpha$ -pattern; supralabials 7–8 ( $\bar{x} = 7.2$ ,  $SD = 0.38$ ,  $n = 36$ ), third-last below centre of eye, separating pre- and postsuboculars; infralabials 6–7 ( $\bar{x} = 6.3$ ,  $SD = 0.45$ ,  $n = 38$ ), first two contacting postmental; ear moderately open, approximately equal to eye height, with 1–4 ( $\bar{x} = 2.4$ ,  $SD = 0.60$ ,  $n = 34$ ), usually two (52.9%), rounded lobules along rostral margin, uppermost two generally largest.

Body scales in 20–22 ( $\bar{x} = 21.8$ ,  $SD = 0.50$ ,  $n = 19$ ), usually 22 (94.4%) longitudinal rows at midbody; scales in paravertebral rows much broader than adjacent lateral dorsal scales, 61–67 ( $\bar{x} = 64.5$ ,  $SD = 1.71$ ,  $n = 19$ ); subcaudal scales 95–101 ( $\bar{x} = 97.0$ ,  $SD = 2.08$ ,  $n = 7$ ); lamellae below fourth toe 14–17 ( $\bar{x} = 15.4$ ,  $SD = 0.98$ ,  $n = 34$ ).

SVL 62.5–231 mm ( $n = 19$ ); AGL/SVL 56.0–67.4% ( $\bar{x} = 61.6\%$ ,  $n = 19$ ); TL/SVL 92.8–105.1% ( $\bar{x} = 99.6\%$ ,  $n = 6$ ; sample comprises juveniles only); FLL/SVL 13.4–



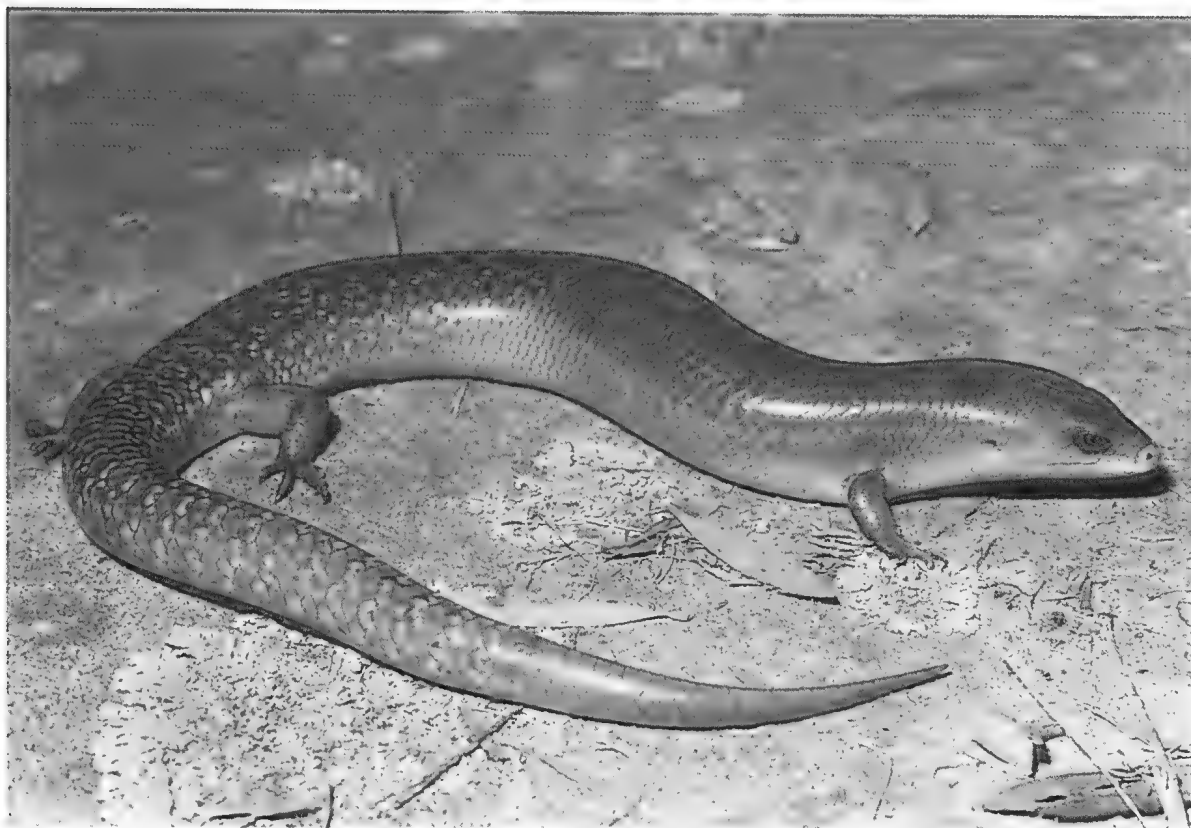


Fig. 11. A live *Cyclodomorphus maximus* from Barnett River Gorge, WA.

21.2% ( $\bar{x}$  = 17.0%,  $n$  = 19); HLL/SVL 18.4–25.6% ( $\bar{x}$  = 21.8%,  $n$  = 19); FLL/HLL 69.7–87.5% ( $\bar{x}$  = 77.3%,  $n$  = 19); HL/SVL 13.1–21.8% ( $\bar{x}$  = 16.8%,  $n$  = 19); HW/HL 65.5–76.9% ( $\bar{x}$  = 72.4%,  $n$  = 19); HD/HL 48.2–57.9% ( $\bar{x}$  = 52.1%,  $n$  = 19).

Presacral vertebrae 40–42 ( $\bar{x}$  = 41.3,  $SD$  = 0.60,  $n$  = 16); postsacral vertebrae 54–55 ( $\bar{x}$  = 54.6,  $SD$  = 0.53,  $n$  = 7); phalangeal formula of manus and pes 2.3.4.4.3.

**Allometry.** With respect to SVL, limb lengths and HL showed negative allometry, while AGL showed positive allometry. With respect to HL, both HW and HD showed significant positive allometry (Table 4).

**Coloration (in preservative).** Yellow-brown, caramel-brown or red-brown dorsally and laterally, with white to cream markings caudally on many scales, tending to align transversely, beginning between  $1/4$ – $1/2$  length of body, and extending over basal  $2/3$ – $3/4$  of tail, where most prominent. Pale markings on a scale generally consist of two broad, widely separated longitudinal streaks, frequently joined by a narrow to broad transverse bar, forming an open rectangle. Head dorsum immaculate; laterally immaculate except for dark brown clouding forming a narrow ring around orbit. Pattern may be obscure in large adults.

Venter light cream-brown to orange-yellow, immaculate or with a few light brown flecks laterally. Palms cream.

Juveniles yellow-brown dorsally and laterally, body

and tail with closely spaced narrow cream bands, formed by wholly or largely pale scales alternating with yellow-brown scales. Nape with broader alternating light and dark bands as follows: a 3–4 scale wide pale band behind parietals, extending laterally to venter, followed by an equally wide light brown band, clouded with dark brown laterally, at and caudal to level of ear, broken behind ear, but reappearing ventrocaudal to ear; a narrow 2–3 scale wide pale band extending laterally to venter, followed by a similarly narrow light brown band, clouded with darker brown laterally, at and slightly cranial to level of forelimbs, followed by an obscure narrow pale band (first band of the body pattern).

Head dorsum yellow-brown, more yellow on snout, darker on crown. Face yellow-brown with a narrow dark circumocular ring; lips cream with brown edges to some scales, temples with a cream patch, extending up from lips.

Venter cream, vent and tail with narrow brown transverse lines, throat and chin with narrow brown vermiculations. Soles of feet unpigmented.

**Coloration (in life)** (Fig. 11): Data are available for one Mitchell Plateau adult (Wilson & Knowles, 1988), the Barnett River Gorge adult (HFW 2144) and one of the juveniles in the series 2288–94. Adults are red-brown dorsally, with the pale “horseshoe” markings light yellow-green to cream. Head dorsum a little paler and greyer than body ground. Laterally body and tail light



Fig. 12. Holotype of *Omolepida maxima* Storr (WAM R27760).

green-grey, with pale markings less distinct; face yellow-brown, cream-yellow over lips. Circumocular ring dark brown. Tip of snout grey-white. Ventrally pale cream-yellow, becoming more yellow on throat. Ventral colour extends dorsally behind axilla and around ventral half of ear. Palms unpigmented. Iris orange-red; tongue blue.

The juvenile had dorsal ground orange-brown with pale markings light yellow, tail yellow distally. Laterally, orange scales become yellowish grey-green, yellow scales remain unchanged, producing an overall grey-yellow hue. Head grey-brown dorsally, more yellow over snout. Bands on nape yellow and orange, the latter clouded with black, especially laterally. Face cream-yellow, with dark brown markings as above. Venter unpigmented, with narrow dark brown bands on tail, and dark brown vermiculations on throat. Iris orange; tongue blue.

**Sexual dimorphism.** Mature-sized males (SVL 155–231 mm,  $\bar{x}$  = 193.8 mm, SD = 29.19,  $n$  = 6) were similar in size to mature-sized females (SVL 159–224 mm,  $\bar{x}$  = 184.0 mm, SD = 35.0,  $n$  = 3; Mann-Whitney U test:  $U$  = 7, n.s.). The available material was too scanty to assess sexual dimorphism in other metric characters.

No significant differences were detected between males and females in mean number of paravertebral scales, subcaudal scales, subdigital lamellae, supralabials, infralabials, postsuboculars, supraciliaries, nuchals, lobules, upper palpebrals or lower palpebrals, or in frequency of contact of parietals.

**Distribution.** *Cyclodomorphus maximus* is restricted to the north-west Kimberley of WA, from Koolan Island in the west to Kalumburu in the east, and south to the Barnett River Gorge (Fig. 14).

**Geographic variation.** The female and litter from Barnett River Gorge, the southernmost locality, have significantly fewer lower palpebrals ( $\bar{x}$ 's = 10.3 vs 11.6,  $t_{14}$  = 3.16\*\*), paravertebral scales ( $\bar{x}$ 's = 63.0 vs 65.3,  $t_{17}$  = 3.58\*\*) and subdigital lamellae ( $\bar{x}$ 's = 14.5 vs 15.9,  $t_{32}$  = 4.86\*\*\*), and a higher proportion of parietals contacting caudal to the interparietal (7:0 vs 2:8; Fisher Exact Probability Test,  $p$  < 0.05) than other material.

**Type material.** The holotype of *C. maximus* (WAM R27760; Figs 12,13) has supraciliaries six, postsuboculars four, nuchals 3/4, supralabials seven, infralabials 6/7, upper palpebrals 11, lower palpebrals 11, rostral ear lobules two, midbody scales 22, paravertebral scales 65, subdigital lamellae 15, SVL 231 mm, AGL 153 mm, tail regenerated, FLL 31 mm, HLL 42.5 mm, HL 30.2 mm, HW 22.2 mm, HD 16.6 mm.

**Comparison with other taxa.** *Cyclodomorphus maximus* differs from all other taxa in the *C. branchialis* species group in its much greater size, from neonates (minimum size 62.5 mm vs 38 mm) to adults (maximum size 231 mm vs 132 mm, for *C. m. melanops*), much longer tail with correspondingly more numerous subcaudal scales (95–101 vs  $\leq 87$ ) and postsacral vertebrae (54–55 vs  $\leq 46$ ), more numerous ear lobules (modally 2 vs 0 or 1) and shorter, narrower interparietal scale, in relation to frontal scale. The overall size and the small interparietal at least are autapomorphies of the species.

*Cyclodomorphus maximus* is similar to *C. celatus* in possessing 20–22 midbody scales, but differs markedly from this species and *C. branchialis* in having more numerous postsuboculars (modally 4 vs 3 in most populations), upper palpebrals ( $\bar{x}$ 's = 10.3 vs 8.5, 8.1), lower palpebrals ( $\bar{x}$ 's = 11.0 vs 9.1 for both) and subdigital lamellae (14–17,  $\bar{x}$  = 15.3 vs 10–15,  $\bar{x}$  = 11.9

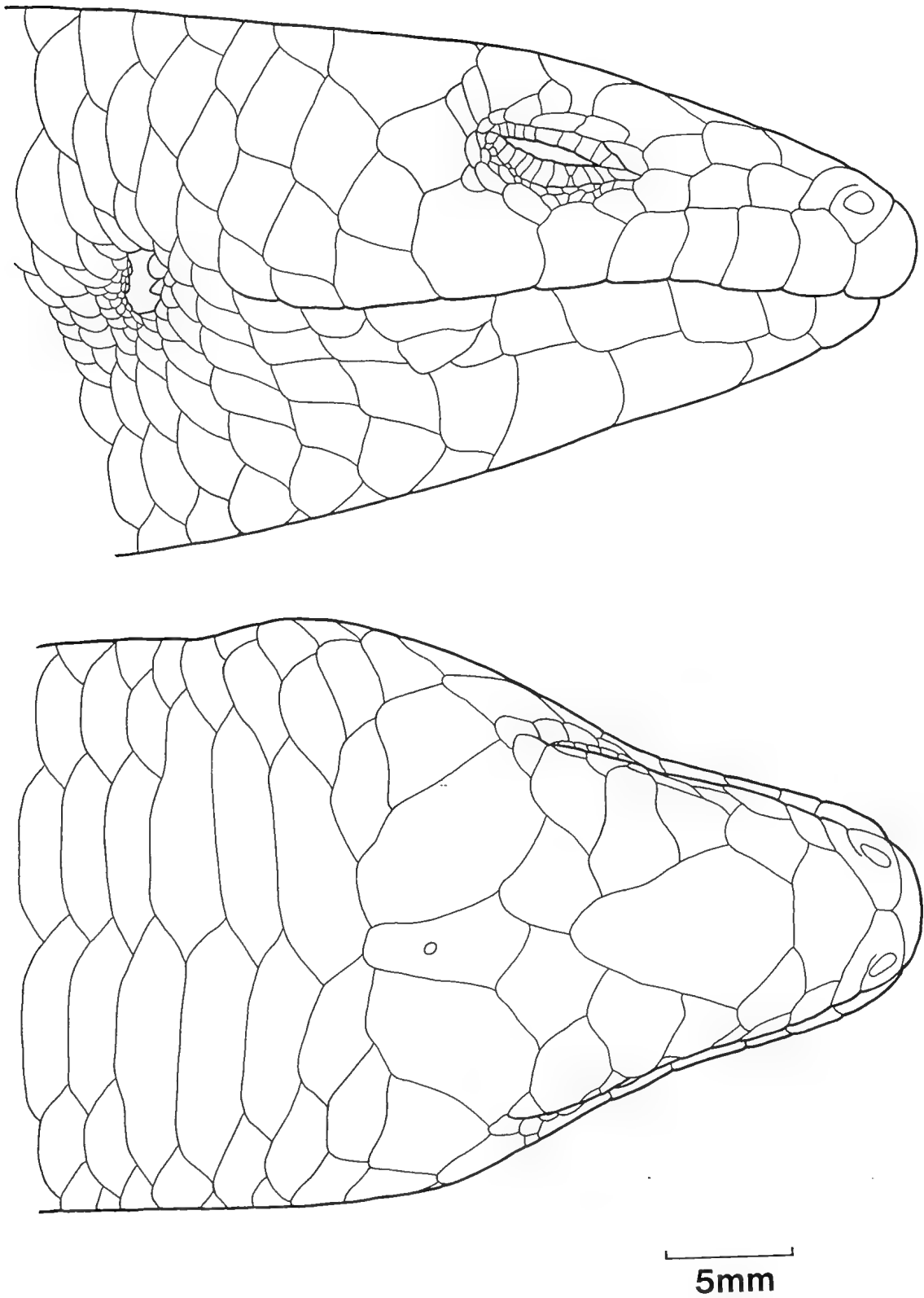
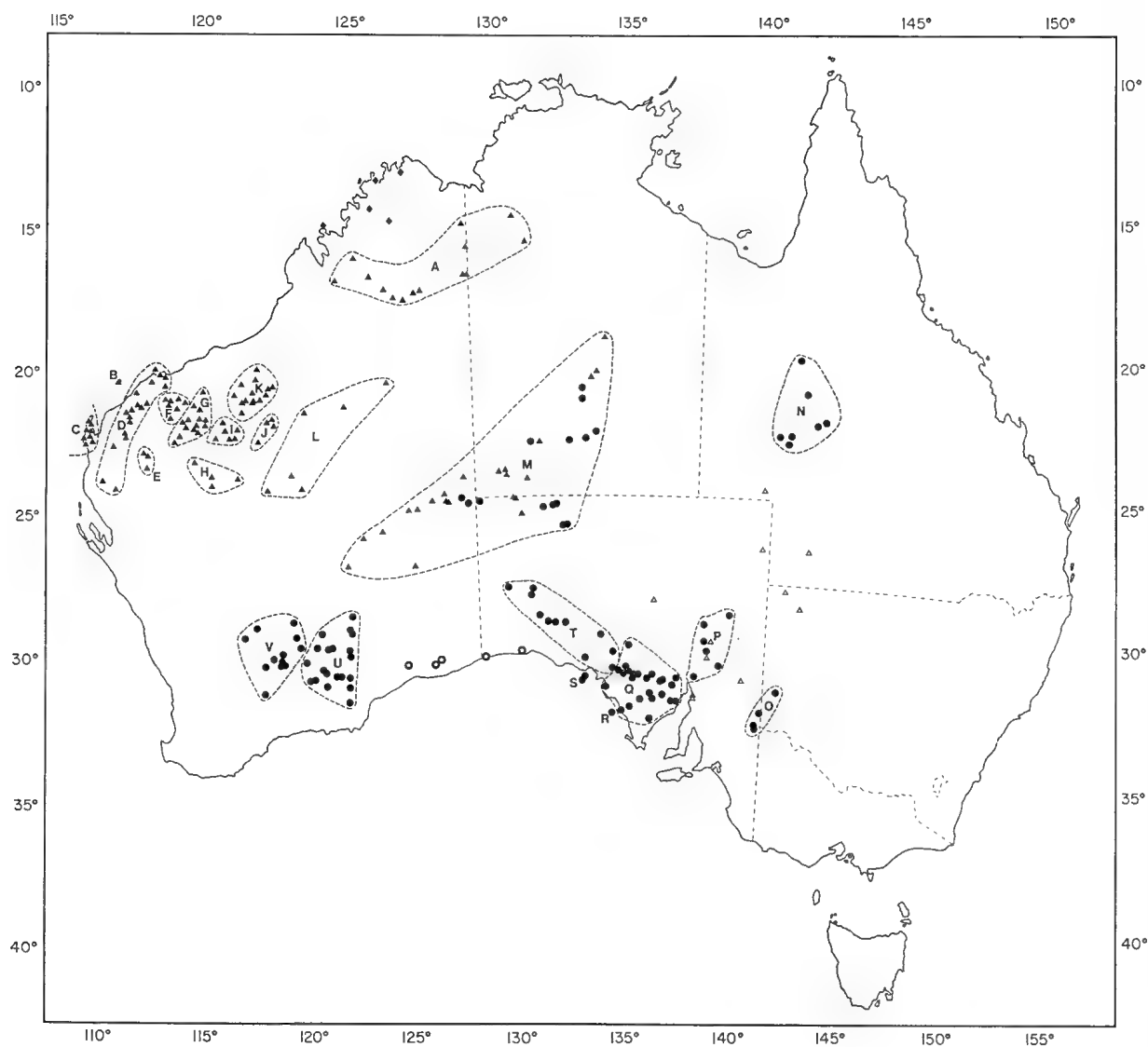


Fig. 13. Head shields of holotype of *Omolepida maxima* Storr.



**Fig. 14.** Distribution of some members of *Cyclodomorphus branchialis* species group: *C. maximus* (diamonds); *C. m. melanops* (closed triangles); *C. m. elongatus* (dots); *C. m. siticulosus* (starred dots); *C. venustus* (open triangles). Dashed lines and letters delimit and identify populations used in defining geographic variation in *C. m. melanops* and *C. m. elongatus*, as follows: A, Kimberley; B, Barrow Island; C, Exmouth; D, Onslow; E, Lower Ashburton; F, Millstream; G, Hamersley; H, Upper Ashburton; I, Mt Newman; J, Talawana; K, Oakover; L, Great Sandy Desert; M, Centralian (both subspecies); N, Queensland; O, NSW; P, Flinders Ranges; Q, Eyre Peninsula; R, Flinders Island; S, Nuyts Archipelago; T, Ooldea; U, Zanthus; V, Boorabbin.

and 9–12,  $\bar{x}$  = 10.8), a broader but shallower head (Tables 1,2,4), dorsal ground more brown than grey, without dark streaks, and a prominent dark circumocular ring. It also has fewer midbody scales than *C. branchialis* (mode 22 vs 24).

**Habitat.** Storr (1976) records *C. maximus* from “sandstone plateaux of north-west Kimberley”, while Ehmann (1992) states that the species “inhabits loose leaf and humus debris that lies between boulders and rocks that are partly overgrown with vines, figs and fringing spear

grass tussock and hummock grass”, in “escarpments of ... sandstone plateaux ... especially around gorges and escarpment outcroppings with extensive broken up and exposed boulder reefs. Vegetation of straggling vines, thickets and figs on these reefs and edges provides deep loose leafy litter and humus in the labyrinths of crevices and tunnels. Adjacent vegetation includes low open eucalypt woodland with figs and boabs”. Specific habitat data are available for most specimens. The holotype was burnt from spinifex on sandstone. The Prince Regent River specimen was taken at site W6 (Youwanjela Creek)

of the WA Department of Fisheries and Wildlife Survey (Miles & Burbidge, 1975), where it was taken in sandstone/spinifex (Storr & Smith, 1975). Site W6 is described by Miles *et al.* (1975: 24): "the slopes of the valley consist of a series of steps made by strongly bedded sandstones supporting a low open-woodland of *Eucalyptus* spp., *Ficus* spp., and Baobab (*Adansonia gregorii*) trees with a ground cover of spinifex hummock grasses. The northern side is much steeper with several ridges along the lower parts and a high vertical rampart at the upper part. Under some of these ridges the vegetation becomes more dense with some vine thicket present ... Upstream from the main campsite about 1.5 km a major fork occurs in Youwanjela Creek ... The valley ridge on either side supports a low woodland of *Eucalyptus* spp. and *Acacia* sp. trees with spinifex hummock grasses."

The Lone Dingo specimen was taken in semi-deciduous vine thicket (Dense Low Forest) on laterite (J. Dell, pers. comm.), while the Walsh Point series was taken in "deciduous vine thicket, between beach and volcanic [basaltic] cliff ... Stratum 1: *Melaleuca leucadendron*, *Ficus platypoda*, *Terminalia petiolaris*, *Albixia lebbek*. Stratum 2: *Gardenia* sp., *Pouteria sericea*, *Calytrix brachychaeta*, *Bombax* sp. Stratum 3: *Flagellaria indica*, *Erythrophleum chlorostachys*" (Kitchener *et al.*, 1981). Both sites have numerous variable size boulders and considerable leaf litter (J. Dell, pers. comm.).

The Barnett River Gorge adult was found under a grass tussock at the entrance to the gorge, near vine thickets (H. Ehmann, pers. comm.).

**Reproduction.** One female (HFWE 2144; SVL 224 mm) gave birth to seven young (HFWE 2288–2294) in early January 1983 (Ehmann, 1992, pers. comm.) although Wilson & Knowles (1988) erroneously report the date as late February. Other apparently mature males ( $n = 6$ ) and females ( $n = 2$ ) were non-reproductive.

**Sex ratio.** The ratio of mature-sized males: mature-sized females in the sample examined is 6:3.

**Diet.** Ehmann (1992) records snails, slugs, cockroaches, isopods, plant material and fruits in the diet, presumably on the basis of captive feeding experiments on the Barnett River Gorge material he collected. Shells of small land snails were the only identifiable remains in the gut of WAM R77631, R77637 and R96112.

**Specimens examined** (all localities are in WA). WAM R27760 (HOLOTYPE) Kalumburu; R46885 (PARATYPE) Youwanjela Creek, Prince Regent River Reserve (15°34'S 125°25'E); R77022, Lone Dingo, Mitchell Plateau; R77042, R77192–93, R77592, R77631, R77637, Walsh Point, Port Warrender; R95558, Mitchell Plateau (14°35'S 125°45'E); R96112, R103732, Koolan Island; HFWE 2144, 2288–2294, Barnett River Gorge.

### *Cyclodomorphus melanops melanops* (Stirling & Zeitz, 1893)

Figs 15–19

*Lygosoma melanops* Stirling & Zeitz, 1893: 173.

*Lygosoma gastrostigma* Boulenger, 1898: 918.

**Diagnosis.** *Cyclodomorphus m. melanops* differs from all other members of the *C. branchialis* species group in the combination of a mode of 24 or more midbody scales, 62–80 paravertebral scales, 66–87 subcaudal scales, moderately large, open ear aperture, usually  $\alpha$ -temporal configuration, grey, grey-brown, yellow-brown or red-brown dorsal ground and black spots at least ventrally, but usually dorsally and laterally as well.

**Description.** Prefrontals rarely narrowly separated (0.5%,  $n = 440$ ) or in narrow contact (0.2%); parietals completely separated by interparietal (98.2%,  $n = 439$ ) or in narrow to broad contact caudally (1.8%); interparietal broadest rostrally, approximately  $2/3$ – $9/10$  length and breadth of frontal; transversely enlarged nuchals 0–5 on each side ( $\bar{x} = 2.8$ ,  $SD = 0.70$ ,  $n = 878$ ), usually three (65.8%); loreals rarely three unilaterally (0.5%,  $n = 429$ ), one unilaterally (2.1%) or one bilaterally (1.2%); supraoculars rarely two unilaterally (0.9%,  $n = 439$ ), or four unilaterally (0.2%) or bilaterally (0.5%); reduction to two due to fusion of first and second supraocular ( $n = 2$ ) or second and third supraocular ( $n = 1$ ); supraciliaries 4–7 ( $\bar{x} = 6.0$ ,  $SD = 0.27$ ,  $n = 875$ ), usually six (93.1%), first and last largest, third last usually projecting between second and third supraocular, remainder moderate, subequal; presuboculars rarely one bilaterally (0.5%,  $n = 440$ ) or unilaterally (0.2%) or three unilaterally (0.5%); postsuboculars 1–5 ( $\bar{x} = 3.9$ ,  $SD = 0.42$ ,  $n = 874$ ), usually four (83.9%); upper palpebrals 7–13 ( $\bar{x} = 9.7$ ,  $SD = 1.07$ ,  $n = 421$ ); lower palpebrals 7–14 ( $\bar{x} = 10.9$ ,  $SD = 1.08$ ,  $n = 419$ ); secondary temporals usually in  $\alpha$ -pattern (96.8%,  $n = 876$ ), rarely in  $\beta$ -pattern (3.2%); supralabials 6–8 ( $\bar{x} = 7.4$ ,  $SD = 0.49$ ,  $n = 875$ ), usually seven (61.3%), third-last below centre of eye, separating pre- and postsuboculars; infralabials 5–8 ( $\bar{x} = 6.3$ ,  $SD = 0.49$ ,  $n = 875$ ), usually six (68.2%), usually first two (92.8%,  $n = 878$ ), rarely first three (6.9%) or first (0.2%) infralabials contacting postmental; ear moderate,  $2/3$ –1 times height of eye, open, oval, with 0–3 ( $\bar{x} = 1.1$ ,  $SD = 0.27$ ,  $n = 872$ ), usually one (92.7%), rounded lobules along rostral margin.

Body scales in 22–28 ( $\bar{x} = 25.4$ ,  $SD = 1.07$ ,  $n = 434$ ), usually 26 (54.5%) longitudinal rows at midbody; scales in paravertebral rows broader than adjacent lateral dorsal scales, 62–80 ( $\bar{x} = 70.0$ ,  $SD = 3.54$ ,  $n = 432$ ); subcaudal scales 66–87 ( $\bar{x} = 74.3$ ,  $SD = 3.87$ ,  $n = 144$ ); lamellae below fourth toe 10–18 ( $\bar{x} = 14.1$ ,  $SD = 1.30$ ,  $n = 782$ ), each with a narrow to broad grey to mid-brown callus.

SVL 41–132 mm ( $n = 427$ ); AGL/SVL 51.2–70.4% ( $\bar{x} = 63.0\%$ ,  $n = 424$ ); TL/SVL 78.3–138.8% ( $\bar{x} = 103.8\%$ ,  $n = 134$ ); FLL/SVL 11.9–22.3% ( $\bar{x} = 16.7\%$ ,

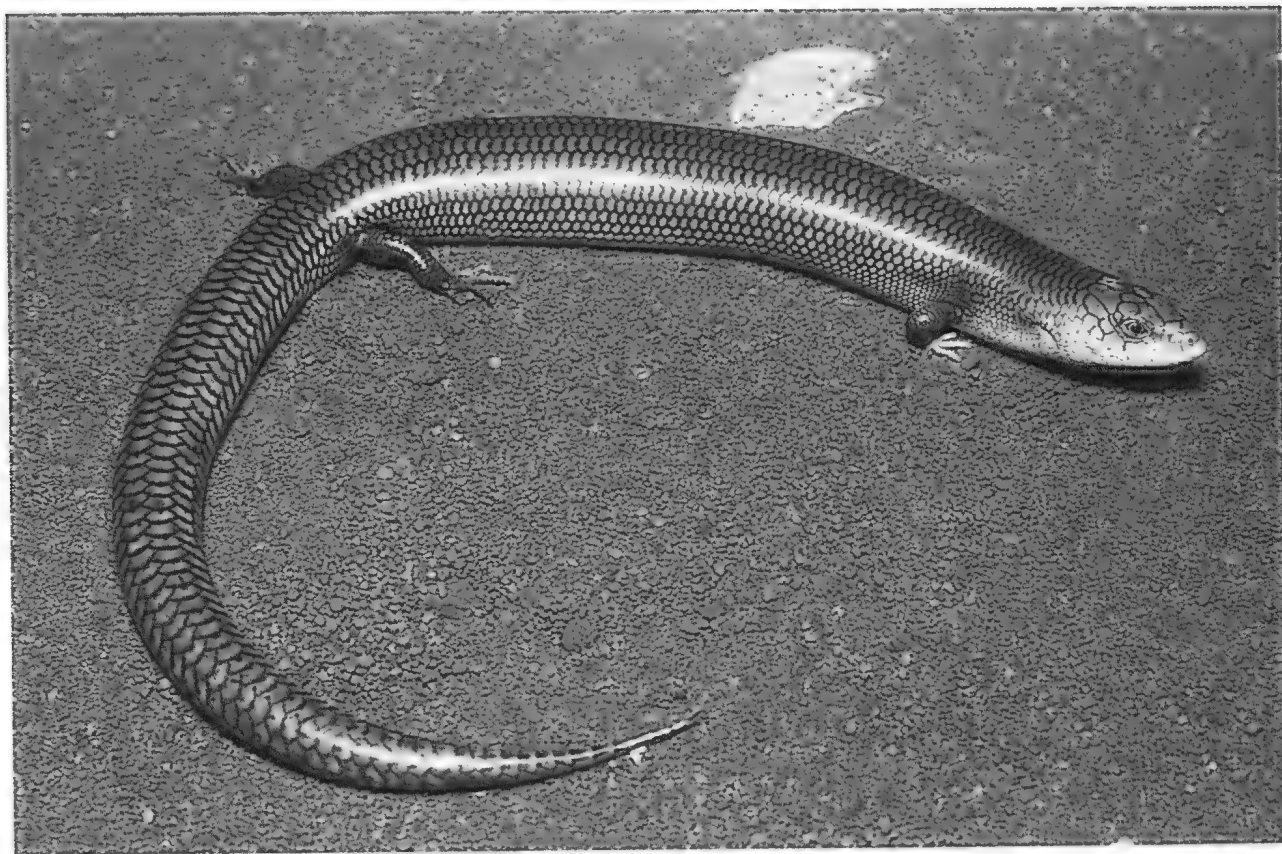


Fig. 15. A live *Cyclodomorphus melanops melanops* from Cane River, WA.

$n = 414$ ); HLL/SVL 16.0–28.0% ( $\bar{x} = 21.8\%$ ,  $n = 414$ ); FLL/HLL 65.0–90.9% ( $\bar{x} = 76.7\%$ ,  $n = 414$ ); HL/SVL 12.1–23.4% ( $\bar{x} = 15.7\%$ ,  $n = 426$ ); HW/HL 59.3–85.6% ( $\bar{x} = 73.5\%$ ,  $n = 431$ ); HD/HL 45.8–67.1% ( $\bar{x} = 56.5\%$ ,  $n = 430$ ).

Presacral vertebrae 38–42 ( $\bar{x} = 39.9$ ,  $SD = 1.14$ ,  $n = 24$ ); postsacral vertebrae 35–46 ( $\bar{x} = 40.6$ ,  $SD = 3.55$ ,  $n = 7$ ); phalangeal formula of manus and pes 2.3.4.4.3.

**Allometry.** With respect to SVL, AGL and TL showed positive allometry, while limb lengths and HL showed negative allometry. With respect to HL, both HW and HD showed slight but significant positive allometry (Table 5).

**Coloration (in preservative).** Light to mid olive brown, red-brown, yellow-brown or grey-brown dorsally, often with a central dark fleck or spot in many body and tail scales. Ventral ground cream to yellow usually with varying degrees of dark brown flecking or spotting, most prominent caudally.

Head and neck immaculate or weakly spotted dorsally, often strongly spotted laterally and on throat. Upper lip usually pale, often with dark streaks and flecks. Orbit sometimes clouded with dark grey-brown.

Palms cream to yellow to light brown with light cream-brown to dark brown calli and tubercles.

Juveniles as adults, but usually with head darker grey-

brown, and white spots midcaudally on many body and tail scales, often aligned in vertical bars laterally and on tail.

**Coloration (in life)** (Fig. 15): Data are available on iris, tongue and mouth colour for a series of 27 Barrow Island specimens (SVL 69–110 mm; L.A. Smith pers. comm.). Iris colour was described as yellow ( $n = 11$ ), yellowish ( $n = 15$ ) and reddish-yellow ( $n = 1$ ). Tongue colour was described as inky-blue ( $n = 22$ ), purplish-blue ( $n = 3$ ), blue-black ( $n = 1$ ) and purplish-red ( $n = 1$ ). Mouth colour was noted as whitish ( $n = 2$ ), pinkish-white ( $n = 3$ ), pinkish ( $n = 6$ ), pink ( $n = 3$ ) and grey ( $n = 1$ ). In WAM R84069, the iris was described as yellowish.

AM R52077 was described as “venter: ground colour pale yellow, becoming white under head, numerous tiny black spots all over; dorsal ground colour greyish-brown with numerous tiny black and white flecks all over; head light grey, becoming darker on sides; legs grey” (P. Rankin field notes).

**Sexual dimorphism.** Mature-sized males (82–126 mm,  $\bar{x} = 95.1$  mm,  $SD = 8.98$ ,  $n = 88$ ) were generally slightly smaller than mature-sized females (83–132 mm,  $\bar{x} = 97.0$  mm,  $SD = 9.17$ ,  $n = 125$ ), although the difference was not significant (Mann-Whitney U test,  $z = 1.401$ ). Males also had generally shorter bodies, but proportionally longer limbs and heads than females, although females had slightly broader heads (Table 6).



Females had significantly greater numbers of paravertebral scales (62–80,  $\bar{x}$  = 70.8, SD = 3.83,  $n$  = 141 *vs* 62–75,  $\bar{x}$  = 68.9, SD = 3.16,  $n$  = 102;  $t_{241}$  = 4.08\*\*\*) but fewer subdigital lamellae (10–18,  $\bar{x}$  = 13.9, SD = 1.31,  $n$  = 257 *vs* 11–18,  $\bar{x}$  = 14.4, SD = 1.35,  $n$  = 183;  $t_{438}$  = 3.89\*\*\*) than males.

There were no significant differences between males and females in mean number of midbody scales, subcaudal scales, supralabials, infralabials, postsuboculars, supraciliaries, nuchals or upper or lower palpebrals.

**Distribution** (Fig. 14). *Cyclodomorphus m. melanops* occurs as three discrete and possibly geographically isolated populations: the southern fringe of the Kimberley, from Jasper Gorge, NT, in the east to "Mt Anderson", WA in the west; central Australia, from 62 km east Neale Junction and 8 km west-north-west Point Salvation in the south-west to Davenport Range, NT, in the north-east, and the Pilbara and adjacent fringe of the Great and Little Sandy Deserts, including the coastal plain and North-West Cape, from Roebourne east to "Warrawagine" and Tobin Lake, south to Carnarvon Range, and west to Kumarina, the Ashburton drainage system, Mt Cahill outcamp and Point Cloates. It also occurs on Barrow Island and Dolphin Island off the Pilbara coastline.

**Geographic variation.** For the purposes of describing geographic variation, the overall distribution was divided into 13 populations, named, from approximately west to east, Barrow Island, Exmouth, Onslow, Millstream, Hamersley, Lower Ashburton, Upper Ashburton, Newman, Talawana, Oakover, Great Sandy, Kimberley and Centralian (Fig. 14). The Onslow, Millstream, Hamersley, Lower Ashburton, Upper Ashburton, Newman, Talawana and Oakover populations are collectively referred to as the Pilbara populations. Significant geographic variation was not detected in mean number of supraciliary scales. In significantly varying characters, the only general trends were for fewer scales (midbody scales, subdigital lamellae, supralabials, palpebrals) in the east, and either fewer (paravertebral scales, midbody scales, supralabials) or more (subcaudals, subdigital lamellae) scales in the most peripheral populations in the west and north.

Paravertebral scales. ANOVA:  $F_{12,419} = 24.235^{***}$ . Means ranged from 66.6 (Barrow Island) to 73.0 (Millstream). The Pilbara, Great Sandy and Centralian populations had similar means, from 69.3 (Upper Ashburton) to 73.0. Within the Pilbara, significant differences were only detected between the means for Upper Ashburton and Millstream, Hamersley, Oakover and Onslow, with only Hamersley adjoining Upper Ashburton. In contrast, the Kimberley, Barrow Island and Exmouth populations ( $\bar{x}$ 's = 66.6–68.0), on the northern and western periphery of the distribution, had significantly lower means than most other populations (Table 7), including the nearest populations.

Midbody scales. ANOVA:  $F_{12,421} = 12.150^{***}$ . Means ranged from 24.4 (Barrow Island) to 26.3 (Talawana). All populations except Barrow Island and Centralian

(mode = 24) had a mode of 26 midbody scales and means above 25.0. With the exception of a significantly lower mean for Kimberley ( $\bar{x}$  = 25.2) than Hamersley and Oakover ( $\bar{x}$ 's = 25.8–25.9), only the Centralian ( $\bar{x}$  = 24.5) and Barrow Island populations were significantly different from other populations (Barrow Island *vs* all but Lower Ashburton, Centralian and Great Sandy; Centralian *vs* Kimberley, Hamersley, Millstream, Newman, Oakover, Onslow and Talawana).

Subcaudal scales. ANOVA:  $F_{11,131} = 13.678^{***}$ . No data were available for the Lower Ashburton population. Means ranged from 69.6 (Centralian) to Kimberley and Exmouth ( $\bar{x}$  = 78.1), with only the latter two and Onslow ( $\bar{x}$  = 76.2), all associated with the northern and western periphery of the distribution, above 74.6. All significant differences involved these three high means (Kimberley and Exmouth *vs* Millstream, Oakover, Upper Ashburton and Centralian; Onslow *vs* the latter two also).

Subdigital lamellae. ANOVA:  $F_{12,770} = 24.731^{***}$ . Means ranged from 12.6 (Centralian) to 15.2 (Exmouth), with a clinal decrease in mean from the north and west (Exmouth, Barrow Island, Onslow, Millstream, Kimberley;  $\bar{x}$ 's = 13.9–15.2) to the east (Centralian, Great Sandy;  $\bar{x}$ 's = 12.6–12.8). The intervening eastern and southern Pilbara populations had intermediate means ( $\bar{x}$ 's = 13.2–13.9). Significant differences were detected between a number of populations with high and low means, with the Exmouth population having a higher mean than all other populations, and a number of other significant differences involving geographically proximate populations (Table 8).

Supralabials. ANOVA:  $F_{12,862} = 22.317^{***}$ . Means ranged from 7.0 (Kimberley, Centralian) to 7.9 (Lower Ashburton). In general, higher means and modes of eight supralabials occurred in the Pilbara populations and those nearby, while low means and modes of seven supralabials occurred in peripheral populations (Barrow Island, Great Sandy, Centralian, Kimberley;  $\bar{x}$ 's = 7.0–7.3). With few exceptions, significant differences involved these low means compared to high Pilbara means (Table 9). In particular, the Centralian and Kimberley populations had lower means than most other populations.

Infralabials. ANOVA:  $F_{12,864} = 7.018^{***}$ . Means ranged from 6.1 (Kimberley) to 6.6 (Exmouth) and 6.7 (Newman). Only these extreme means were significantly different to other means (Exmouth *vs* Barrow Island, Hamersley, Oakover, Upper Ashburton, Centralian and Kimberley; Newman *vs* the latter three; Kimberley *vs* Barrow Island, Hamersley, Millstream, Oakover and Onslow), with few of the significantly different pairs involving geographically proximate populations.

Postsuboculars. ANOVA:  $F_{12,862} = 5.336^{***}$ . Four postsuboculars was modal for all populations. Means for most populations ranged from 3.7 (Talawana) to 4.0 (Lower Ashburton, Newman), without significant differences between populations. Only Upper Ashburton ( $\bar{x}$  = 3.5) had a significantly lower mean than other populations (*vs* all but Great Sandy and Talawana).

Nuchals. ANOVA:  $F_{12,865} = 8.770^{***}$ . Three nuchals was modal for all populations. Means ranged from 2.5





Fig. 16. Paralectotype of *Lygosoma melanops* Stirling & Zeitz (SAM R8139).

(Kimberley) to 3.2 (Barrow Island), with only these two peripheral populations significantly different to any others (Kimberley vs Barrow Island, Exmouth, Hamersley, Millstream, Oakover, Onslow and Upper Ashburton; Barrow Island vs Centralian, Exmouth, Hamersley and Oakover).

Upper palpebrals. ANOVA:  $F_{12,408} = 8.789^{***}$ . Means ranged from 8.5 (Lower Ashburton) to 10.4 (Kimberley), with most in the range 9.2–10.1 and without significant differences. With the exception of the Kimberley population (significantly different to Oakover and Upper Ashburton), all significant differences involved the three lowest means (Lower Ashburton, Barrow Island, Centralian;  $\bar{x}$ 's = 8.5–9.2), all three significantly different to Kimberley, Exmouth, Hamersley, Millstream and Onslow, Centralian also different to Oakover. Apart from the peripheral Lower Ashburton mean, none of the significantly different pairs involved geographically contiguous populations.

Lower palpebrals. ANOVA:  $F_{12,406} = 7.490^{***}$ . Means ranged from 9.4 (Great Sandy) to 11.7 (Talawana), with only these and the Centralian mean ( $\bar{x} = 9.7$ ) outside the range 10.0–11.5. Apart from Onslow ( $\bar{x} = 11.5$ ) vs Barrow Island, Lower Ashburton and Upper Ashburton ( $\bar{x}$ 's = 10.0–10.6), the only significant differences involved the Centralian and Great Sandy populations, both in the extreme east of the distribution, with lower means than Exmouth, Hamersley, Kimberley, Millstream, Oakover, Onslow and Talawana, and also Newman and Barrow Island in the case of the Centralian population.

Snout-vent length. Exmouth animals were generally larger than in other populations (mature-sized individuals, 91–132 mm vs 82–128 mm).

Coloration. There was much geographic variation in dorsal ground and degree of dark spotting. Kimberley animals were mid to dark brown dorsally and laterally, the dark flecks usually weak or absent on the body. When present, the flecks were usually restricted to the caudal half of the body, rarely over the whole dorsum, and were located in the middle of the scales, either over the caudal half, or full-length. Dark flecks continued onto the tail, where they were more prominent, and often occurred in pairs on a single scale. The venter had dark flecks from throat to tail tip, sometimes aligned to form stripes on the throat, and often prominent on lips and face. The pale juvenile spots persist to subadults.

Barrow Island individuals were olive-brown, occasionally grey-brown dorsally, pale yellow below. The dorsum usually had scattered very fine dark flecks, on body scales in the middle of the cranial half, but on tail scales in the middle of the distal half. The venter was as for the Kimberley population.

Pilbara material was usually mid grey-brown dorsally, head and cranial half of body often immaculate, sometimes with dark body spots, caudal half of body and tail with weak to strong broad dark spots cranially in many body and tail scales. The dorsal body scales often had darker margins, forming a weak dark reticulum. The venter was cream, usually with, occasionally without dark flecks and streaks, most prominent caudally, very weak (if present) on chin and throat. Juveniles were mid-brown to yellow-brown above with weak dark spots, pale spots on every second body scale caudal to nape, face and lower lips with black clouding. Adults from the Kumarina series differed in their weaker dark flecking, largely confined to the tail, and ventrally to tail and pelvis,

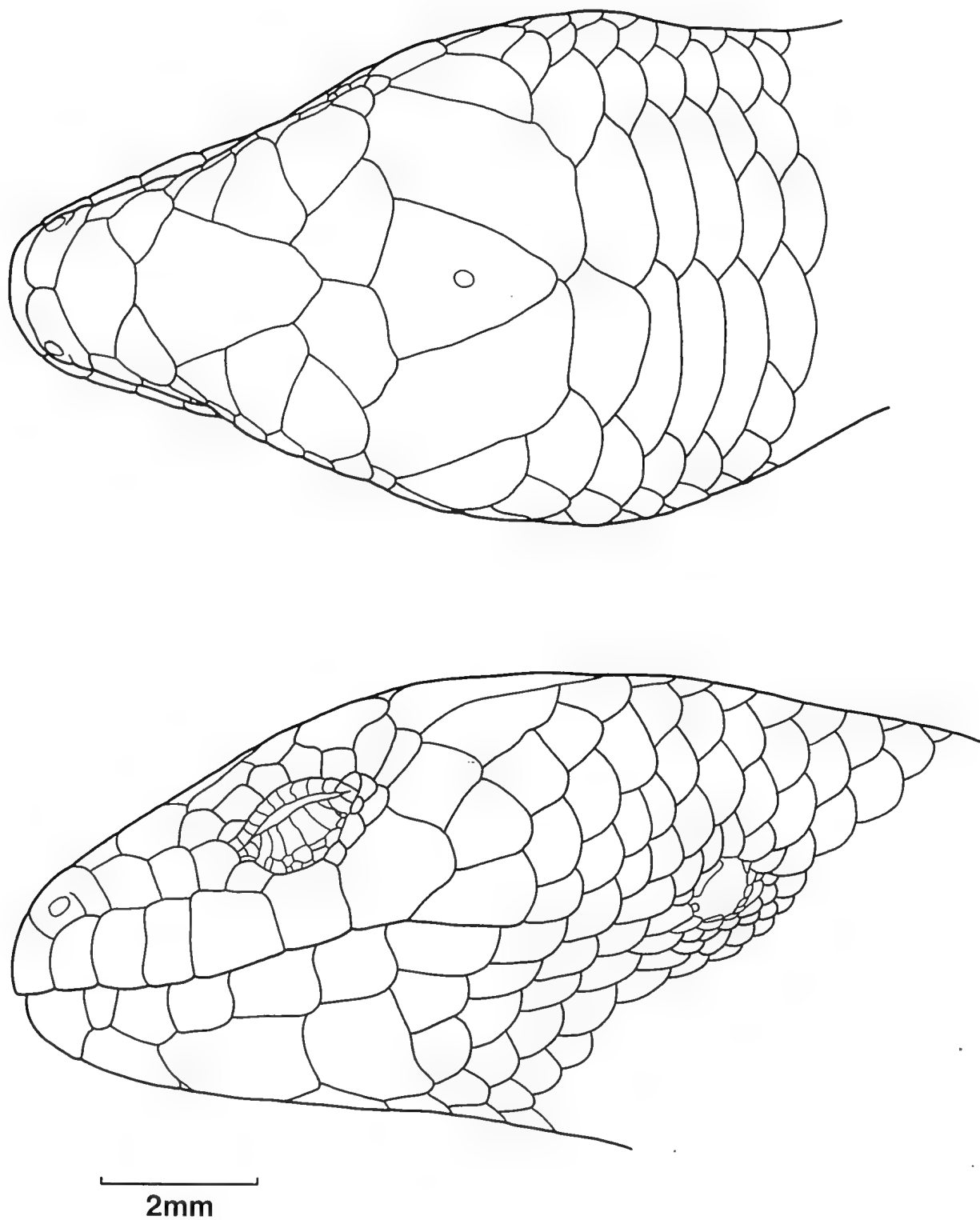


Fig. 17. Head shields of paralectotype of *Lygosoma melanops*.



Fig. 18. Holotype of *Lygosoma gastrostigma* Boulenger (BMNH 1946.8.9.87).

although juveniles had more prominent dark flecking, extending more cranially, sometimes to the chin ventrally.

Exmouth material was usually grey-brown, rarely mid-brown dorsally, head and body usually immaculate, occasionally with a few dark spots cranially in scales on caudal half of body. The tail usually had similar dark spots on every second or third scale. The venter was cream, frequently with dark spots from mid-body to tail, occasionally with dark flecks on chin and throat. Juveniles had pale spots on tail, less prominently on caudal half of body.

Centralian animals were light to mid-brown or yellow-brown dorsally, tail yellowish, with strong dark cranially-situated streaks or spots on most body and tail scales. Venter and lips were cream to pale yellow, with numerous dark flecks and macules, smaller and sparser than on dorsum, weakest on throat, where often aligned in obscure stripes. Juveniles had very prominent pale spots.

**Type material.** *Lygosoma melanops* Stirling & Zeitz, 1893 was described from two specimens collected by the Elder Expedition between the Everard and Barrow Ranges, without specific holotype designation. The description of both adult and juvenile coloration implies that the two syntypes are adult and juvenile, although only the measurements of the adult are provided. Mitchell (1950) identified two specimens, both registered SAM R2732 as types, and provided an illustration of the head of the "holotype". Houston (1976), however, only records a single specimen, which could not be located, under SAM R2732, with a juvenile (SAM R8139) identified as a "paratype". Recent thorough searches of the SAM collection by the authors have also failed to find SAM R2732.

The original register entry for R2732 refers to a single specimen as "type specimen". This has been later corrected in pencil to two type specimens, and "(syntypes)" added after the entry. The register entry for R8139,

registered in 1966, provides a date, 24.vi.1891, and describes the specimen as a paratype. Amongst Mitchell's notes on SAM *Tiliqua* and *Egernia* material, on which his 1950 paper was based, only a single set of data is recorded for R2732: 24 midbody scales, snout-forelimb into axilla-groin,  $2\frac{1}{3}$ – $2\frac{1}{2}$  times, colour bleached white, scalation typical, measurements 148 (83 + 65) mm. The measurements recorded by Mitchell, particularly the tail length, are similar to those recorded by Stirling and Zeitz.

The simplest explanation for the discrepancies between the type description, SAM registers, Mitchell's notes and 1950 paper, and Houston's (1976) listing is that at the time Mitchell was gathering data for his paper, he was initially only able to locate the adult type, which he registered in series with other *Tiliqua* and *Egernia* material, but subsequently found the juvenile, which he also included under that number, as was his registration policy, necessitating the pencilled corrections to the register entry. Subsequent to 1950, the juvenile was probably found separated from the adult, and re-registered as paratype, following Mitchell's (1950) labelling of the head drawing as "holotype". The erroneous labelling of this drawing appears to qualify as lectotype designation (Article 74[b] of the Code of Zoological Nomenclature). We have examined SAM R8139, and it is clear that the head drawing is not of this specimen. Presumably, Mitchell's illustration is of the adult specimen SAM R2732, and the lectotype must be presumed lost. Despite this loss, it is possible to unambiguously assign the name *Lygosoma melanops* to the taxon here described. The description and plate provided by Stirling & Zeitz (1893) clearly note a spotted rather than streaked colour pattern, while Mitchell's (1950) figure illustrates the  $\alpha$ -temporal condition.

The paralectotype, SAM R8139, was invalidly designated lectotype by Wells & Wellington (1985). This specimen (Figs 16,17) is also representative of the

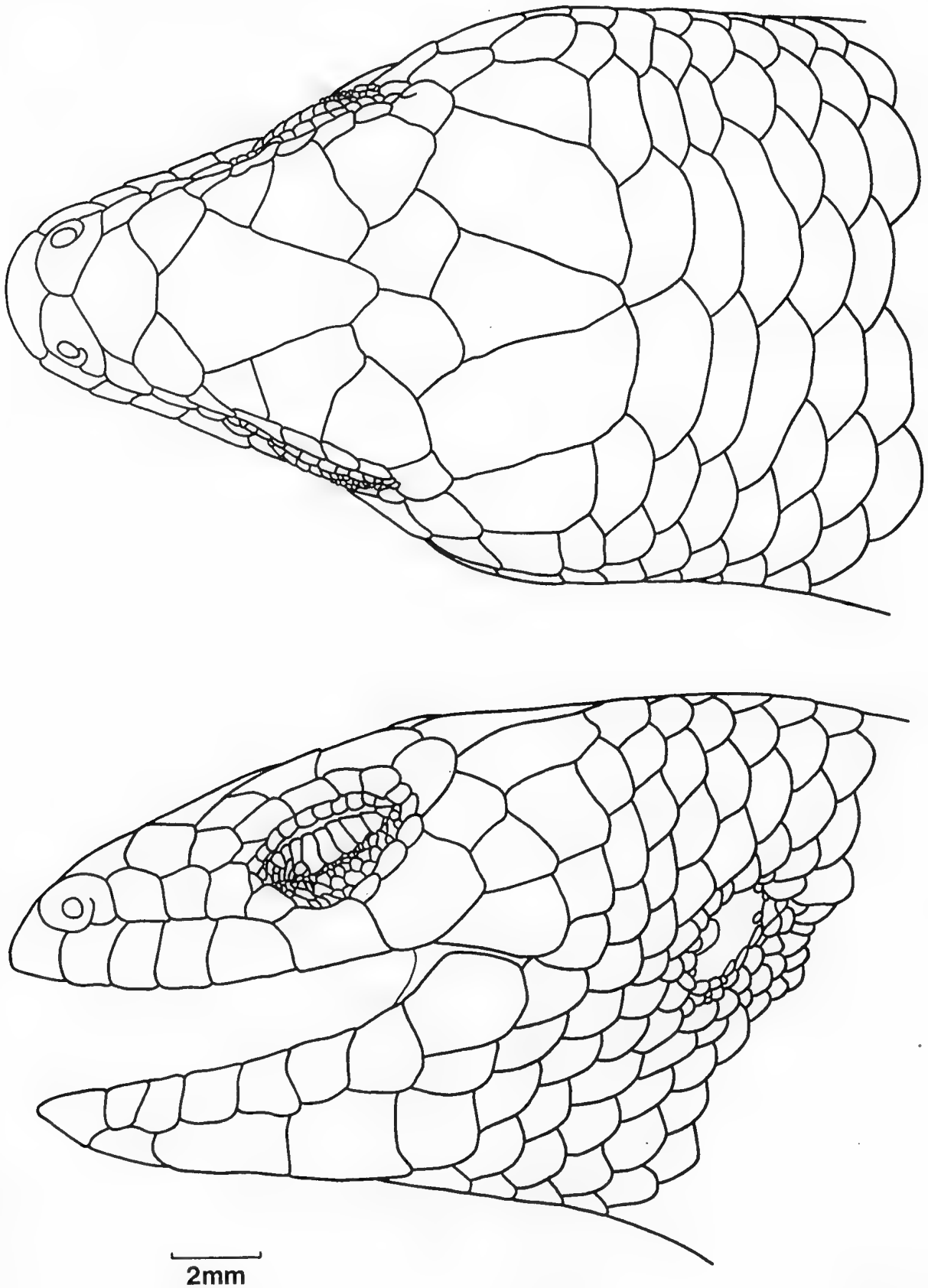


Fig. 19. Head shields of holotype of *Lygosoma gastrostigma*.

subspecies here described, and has supraciliaries six, postsuboculars four, nuchals 4/3, supralabials seven, infralabials six, upper palpebrals ten, lower palpebrals ten,  $\alpha$ -configuration of secondary temporals, midbody scales 24, paravertebral scales 70, subdigital lamellae 12, presacral vertebrae 40, SVL 49.5 mm, AGL 29 mm, tail regenerated FLL 9.5 mm, HLL 11.5 mm, HL 9.1 mm, HW 6.6 mm, HD 5.4 mm. Approximately 10 mm caudal to the axilla is a deep constriction, possibly where another tag was previously tied. Such a missing tag could explain the date assigned to this specimen in the register, which is not mentioned in other literature. On 24.vi.1891, the main party of the Elder Expedition, including the naturalist, Richard Helms, travelled from Camp 8 to Camp 9, at Turner Hill, SA, between 0900–1000hrs, then spent the rest of the day about Camp 9 (Lindsay, 1893). No mention is made of the vegetation at this locality, but the habitat to the north-west of Camp 8 consisted primarily of spinifex on red sand ridges and plains, suitable for *C. m. melanops*. Accordingly, we restrict the type locality for *Lygosoma melanops* to the vicinity of Turner Hill, SA (27°20'S 130°52'E).

*Lygosoma (Homolepida) gastrostigma* Boulenger, 1898 was described from a single specimen from Sherlock River, Nicol [sic] Bay, WA, collected by Dr E. Clement. The holotype (BMNH 1946.8.9.87; Figs 18,19) agrees well with the type description and figures, and is representative of the Onslow population of *C. m. melanops*. The holotype has supraciliaries six, postsuboculars 4/3, nuchals three, supralabials 7/8, infralabials seven, upper palpebrals 10, lower palpebrals 11,  $\alpha$ -configuration of secondary temporals, midbody scales 26, paravertebrals 75, subcaudal scales 77, subdigital lamellae 14/13, presacral vertebral 42, postsacral vertebrae 43, SVL 112 mm, AGL 74 mm, TL 119 mm, FLL 17.5 mm, HLL 23 mm, HL 15.4 mm, HW 11.8 mm, HD 9.5 mm. The difference between the total length as measured by Boulenger (1898) and ourselves (245 mm vs 231 mm) is undoubtedly due to a "soft" section at midbody, allowing stretching of the specimen.

**Comparison with other taxa.** *Cyclodomorphus m. melanops* differs from *C. branchialis* in possessing more numerous postsuboculars ( $\bar{x}$  = 3.9 vs 2.6), upper palpebrals ( $\bar{x}$  = 9.7 vs 8.1), lower palpebrals ( $\bar{x}$  = 10.9 vs 9.1), paravertebral scales ( $\bar{x}$  = 70.0 vs 65.2), subcaudal scales (66–87 vs 57–64) and subdigital lamellae ( $\bar{x}$  = 14.1 vs 10.8), usually an  $\alpha$ -configuration of the secondary temporals, a generally slightly larger ear aperture, and in lacking dark "gill" markings laterally on the neck. The differences in paravertebral and subcaudal counts are paralleled by differences in axilla-groin length and tail length, and in pre- and postsacral vertebrae. *Cyclodomorphus m. melanops* is a much larger taxon than *C. branchialis* (maximum SVL 132 mm vs 88 mm). The two taxa are separated by the Gascoyne drainage, which has hard soils and lacks *Triodia*, and is generally unsuitable for either taxon. The coastal districts between the distributions of the two are occupied by *C. celatus*.

*Cyclodomorphus m. melanops* differs from *C. celatus* in having a mode of 26 (24 on Barrow Island and in Central Australia) midbody scales (vs 22; ranges and means 22–28,  $\bar{x}$  = 25.4 vs 20–24,  $\bar{x}$  = 21.8), a larger, more open ear aperture, more numerous subdigital lamellae (10–18,  $\bar{x}$  = 14.1 vs 10–15,  $\bar{x}$  = 11.9), a longer tail and slightly broader head (Tables 2,5), dark markings usually absent on head and nape, and in the form of spots rather than streaks on body (vs nape and body, and often head, with dark streaks), and in many populations, a greater mean number of supralabials.

The coloration differences are less obvious in juveniles, with their reduced dark flecks, and in the Centralian adults, which are often similar to *C. celatus*. Juveniles can be differentiated by the extension of the dark head "hood" ventrally over the sides of the neck in *C. celatus*, while the Centralian adults have a more brown to yellow dorsum (vs usually grey in *C. celatus*), either lack the streaked "gill" markings or have them very reduced or disrupted, and have the dorsal markings generally in the form of spots rather than streaks.

The two taxa approach each other in the Lake Macleod region, where *C. celatus* has been recorded as far north as 0.5 km south of "Gnaraloo", along the coastal strip, while *C. m. melanops* extends as far south as Point Cloates coastally, and 6 km south-east of "Manberry" and "Mt Cahill" Outcamp to the east of Lake Macleod, a separation of only 125 km and 75 km respectively (Fig. 4).

The seven *C. celatus* from "Gnaraloo" and "Boolathana" have 7–8 ( $\bar{x}$  = 7.2) supralabials, 21–22 ( $\bar{x}$  = 21.9) midbody scales, 10–13 ( $\bar{x}$  = 11.6) subdigital lamellae, the characteristically small, slit-like ear, and head, nape and body heavily dark streaked on a light grey dorsal ground. The largest specimen has SVL = 105 mm.

The three *C. m. melanops* from Point Cloates and "Ningaloo" have 8, 8 and 7/8 supralabials, 26 midbody scales, 12–16 ( $\bar{x}$  = 14.3) subdigital lamellae, a large, open ear, and head and neck immaculate. The largest has SVL = 127 mm, typical of the Exmouth population.

The five *C. m. melanops* from "Manberry" and "Mt Cahill" Outcamp have 7–8 ( $\bar{x}$  = 7.4) supralabials, 24–27 ( $\bar{x}$  = 25.2) midbody scales, 13–17 ( $\bar{x}$  = 14.9) subdigital lamellae and additionally have dorsal ground much more brown than the "Gnaraloo" *C. celatus*.

*Cyclodomorphus m. melanops* is the geographically closest taxon to *C. maximus*, and the most geographically proximate population, Kimberley, shows a slight trend towards *C. maximus* in a number of characters, including low numbers of paravertebral scales, midbody scales, supralabials, infralabials and nuchals, high numbers of subcaudal scales, subdigital lamellae and upper palpebrals, reduction in degree of dark dorsal spotting and flecking, and the frequent retention of pale spots in subadults. However, in addition to the marked differences in overall size, tail length, number of ear lobules and interparietal proportions, *C. m. melanops* differs from *C. maximus* in having a higher modal number of midbody scales (24 or 26 vs 22), dark dorsal spots but no pale dorsal spots

in adults, and a slightly deeper head (Tables 4,5). Known localities for the two taxa are separated by approximately 165 km (Barnett River Gorge vs "Napier Downs").

**Habitat.** *Cyclodomorphus m. melanops* appears to be primarily a *Triodia*-inhabiting form (Butler, 1970; Smith, 1976; Storr & Hanlon, 1980; Heatwole & Butler, 1981; Johnstone, 1983; Storr & Harold, 1985). Of 234 specimens for which microhabitat was recorded, 220 (94.0%) were taken from dead or living *Triodia* or *Plectrachne* tussocks, or from bulldozed *Triodia* spoil, while an additional 16 records were collected in habitats noted as containing *Triodia*. Of the 14 records not taken from hummock grasses, four (WAM R47549, R52946, R63124, R63158) were taken under rubbish, three (WAM R80176, R80247, R85040) in "spoil" (not further described), three (WAM R68360–62) in post-cyclone flood debris, one (WAM R80253) under "litter" in *Triodia* habitat, one (WAM R74882) under a soft-grass tussock, one (WAM R47552) from *Spinifex longifolius* and one (AM R100679) from an *Acacia* litter mat in *Triodia* habitat.

The substrate, topography and extra-*Triodia* vegetation associations inhabited by *C. m. melanops* are quite varied. The Kimberley and Pilbara populations mostly occur on stony to rocky substrates ( $n = 50$ ), both on plains ( $n = 4$ ) and slopes ( $n = 5$ ; WAM R58250: "limestone range"), although it has also been recorded from other substrates (WAM R51717: red sandy soil; WAM R51723: reddish sandy loam; WAM R73972: sandy colluvium; WAM R74074–79: slightly stony, loamy soil; WAM R73941–44: loamy flat; WAM R74882: clay flat), and about the margins or floodplains of seasonally dry rivers and streams ( $n = 6$ ). The vegetation of such substrates is varied, and includes mulga/*Triodia* or *Plectrachne* ( $n = 4$ ) or other *Acacia* species (WAM R80798: "*Acacia xiphophila*, hummock grass on gravelly soil"); mallee/*Triodia* (WAM R73149: "open shrub mallee over *Triodia basedowii* on gibber and loam") and other eucalypts (WAM R81366–70: "sparse eucalypts over spinifex on stony red soil"). Other described vegetations include "open shrubland/woodland with spinifex, on hard pebble, red sand" (AM R100679); "open savannah grassland on red sandy soil" (CAWC R805–06, WAM R60229–33) and "low shrubs/*Triodia* on red sandy loam" (WAM R71651).

Further to the west, the Onslow and Exmouth populations largely occur on sandy substrates, both dunes ( $n = 6$ ; WAM R61109–12: "light soil behind coastal dunes"; AM R101631: "red sand dunes with locally outcropping limestone") and plains ( $n = 2$ ; WAM R61248–50: "light yellowish soil plain"), with a variety of vegetation associations (WAM R71487–89: "*Acacia/Triodia* on red dune"; WAM R76421, R78944: "hummock grassland dominated by *T. angusta* on sandy substrate"; WAM R80176: "*Eucalyptus camaldulensis* woodland over open shrubs on brown sandy loam"; WAM R80247: "sparse low shrubs on red sandy loam"; WAM R85040: "open *Eucalyptus microtheca* over open *Acacia* and *Triodia* on red loam"). One specimen was recorded from harder substrates (WAM R81306: stony red clay).

To the east of the Pilbara, the Great Sandy Desert and more western Centralian populations also largely inhabit sandy substrates ( $n = 1$ ), both dunes ( $n = 6$ ; WAM R63539: "desert oaks over spinifex on dune slope") and plains (WAM R63947: "mallee over mulga over spinifex, sandy loam plain with anthills"), although harder substrates have been recorded, particularly for the more eastern Centralian populations (AM R52074–76: sandstone hills; "rocky ground at foot of range"; Smith & Johnstone, 1979; WAM R63771: "mallee over shrubs over mulga over melaleuca; loamy sand, gravel and pebbles"; WAM R20790: "mulga flat"; CAWC R1017: "sandy burnt area of *Thryptomene maisonneuvei*; spinifex on occasional sandstone outcrops").

**Reproduction.** There has been little published on reproduction in *C. m. melanops*. Smith (1976) recorded reproductive activity in gonads of Barrow Island specimens collected 17 August–13 September, with up to 5 enlarged ovarian follicles, while Heatwole & Butler (1981) record a single full-term embryo in a Barrow Island female collected 6 February. Pianka (1986) records a single litter of 3.

Male reproductive cycles in *C. m. melanops* are strongly seasonal (Fig. 20). Enlarged turgid testes  $\geq 5.0$  mm in length were present in most mature-sized males collected between May and September, with testis length peaking in late August–early September. Testes of mature-sized males collected outside this period were generally small and flattened.

Female reproductive cycles are similarly seasonal (Fig. 21). Only one of 34 mature-sized females collected between 12 March and 18 August showed signs of reproductive activity. Most females collected in late August–early September showed an increase in size of ovarian follicles, and enlarged yolking ovarian follicles were present between 22 September and 26 November. Unshelled oviducal eggs and developing embryos were present between 17 October and January, with a single record of full-term young on 8–11 March, although all late January and February specimens were non-gravid, suggesting that parturition had generally occurred by then.

We conclude from the above data that spermatogenic activity reaches a peak in late August, coinciding with mating and fertilisation, and young are born in January, following approximately 4 months gestation.

Only four of 24 mature-sized females collected in October and November were not gravid, suggesting that breeding generally occurs annually.

Gravid females carried 1–4 ( $\bar{x} = 2.6$ , mode 3 [46.4%],  $n = 31$ ) enlarged yolking ovarian follicles, unshelled oviducal eggs or fully developed embryos. Litter size was not significantly related to maternal SVL ( $r = 0.2270$ ,  $P = 0.245$ ).

**Growth rates.** Seasonal distribution of body sizes in the material examined (Fig. 22) indicates a clear year 1 cohort, and suggests that a SVL of about 82–83 mm

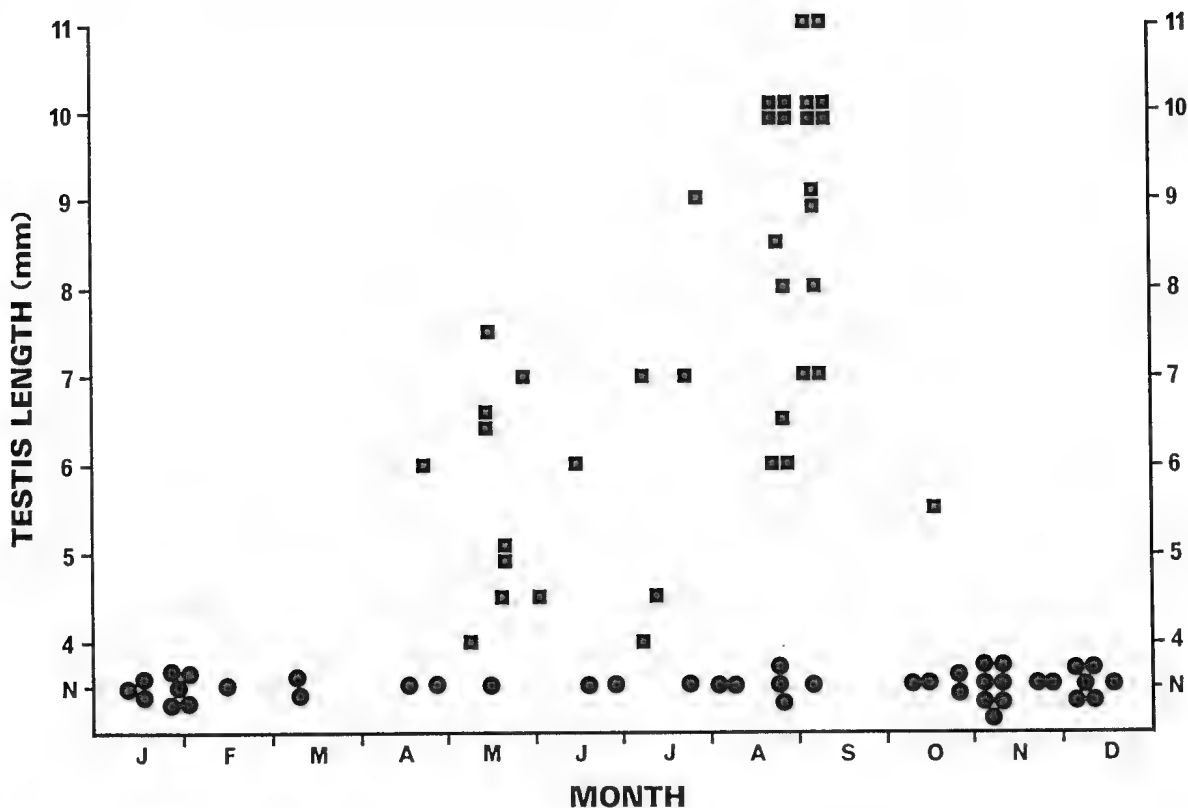


Fig. 20. Seasonal variation in length of turgid testes, and the occurrence of flaccid testes in *Cyclodomorphus melanops melanops*.

(size at maturity) is reached in the second or third year.

**Sex ratio.** The sex ratio of mature-sized material examined is 87 males : 127 females, significantly different from 1:1 ( $\chi^2_1 = 7.11^{**}$ ). An excess of females is present in both northern (Kimberleys; 12:14) and southern material (Pilbara, 48:73, Barrow Island, 18:26, Centralian and Great Sandy 9:14) and in southern seasonal samples (summer 8:17, autumn 11:15, winter 27:43, spring 27:38). Seasonal sex ratios are not significantly different to each other ( $4 \times 2$  contingency table,  $\chi^2_3 = 0.81$ , n.s.).

**Diet.** The diet of the Barrow Island population includes annelids, spiders, roaches, termites, lepidoptera and beetles (Smith, 1976), while the stomachs of six Centralian specimens contained 54% termites, 16% grasshoppers/crickets, 13% beetles, 8% bugs, 4% roaches, 2% lepidoptera, 3% unidentified arthropods, and <0.5% each of spiders, ants, insect larvae and vertebrates (Pianka, 1986).

**Specimens examined.** KIMBERLEYS: AM R45605-07, MV D42000-02, WAM R47490-501, R47504-15, Lake Argyle, WA; AM R76648, Jasper Gorge, NT; CAWC R805-06, WAM R60229-33, Spring Ck, c. 58 km north "Wave Hill", NT; NTM R6652-60, Nicholson River Gorge, "Nicholson", WA; R7032-

34, between Fitzroy Crossing and Halls Creek, WA; R7277-81, 167 km east Fitzroy Crossing, WA; WAM R23038-39, 26 km south-south-east "Gogo", WA; R27759, "Mt Anderson", WA; R46051-54, 76 miles south-west Halls Creek, WA; R46111-12, "Margaret River", WA; R57121, 22 km north "Mistake Creek", NT; R57161, 67 km south-west Halls Creek, WA; R58250, "Napier Downs", WA; R60292, 3 km south-east "Nicholson", WA; R70489-90, 64.0 km 265° "Louisa Downs", WA; R79064-65, "Brooking Springs", WA. BARROW ISLAND, WA: WAM R27757-58, R28460, R28684-91, R47546-84, R47850, R56678-86. EXMOUTH, WA: AM R81284, Yardie Creek camp; R101631, just west of "Bullara"; R101959, "Yardie Creek"; WAM R13199, R13232, Point Cloates; R21767-69, 25 miles north-east "Ningaloo"; R22402, 8 miles south Learmonth; R22403, 5 miles south Learmonth; R22404, 3 miles south Learmonth; R27752-55, "Yardie Creek", 40 miles south homestead; R31416, presumably vicinity of Exmouth; R32029, 2 miles east Norwegian Bay, "Ningaloo"; R51013-14, Exmouth; R51015, "Bullara", R52932, Shothole Canyon, Cape Range; R52946, Vlaming Head Lighthouse, Exmouth; R61109-12, 9 km north Yardie Creek; R61248-50, 14 km north Yardie Creek; R61271, R88634, 3 km north-west "Bullara"; R61426-27, R88619, Yardie Creek mouth; R83154-61, "Yardie Creek".

PILBARA, WA: ONSLOW: AM R49082, Roebourne; R123076-77, 6.7 km south Cane River crossing on hwy; BMNH 1946.8.9.87, Sherlock River, Nickol Bay (type of *Lygosoma gastrostigma*); SAM R22881, 12 km south Barradale



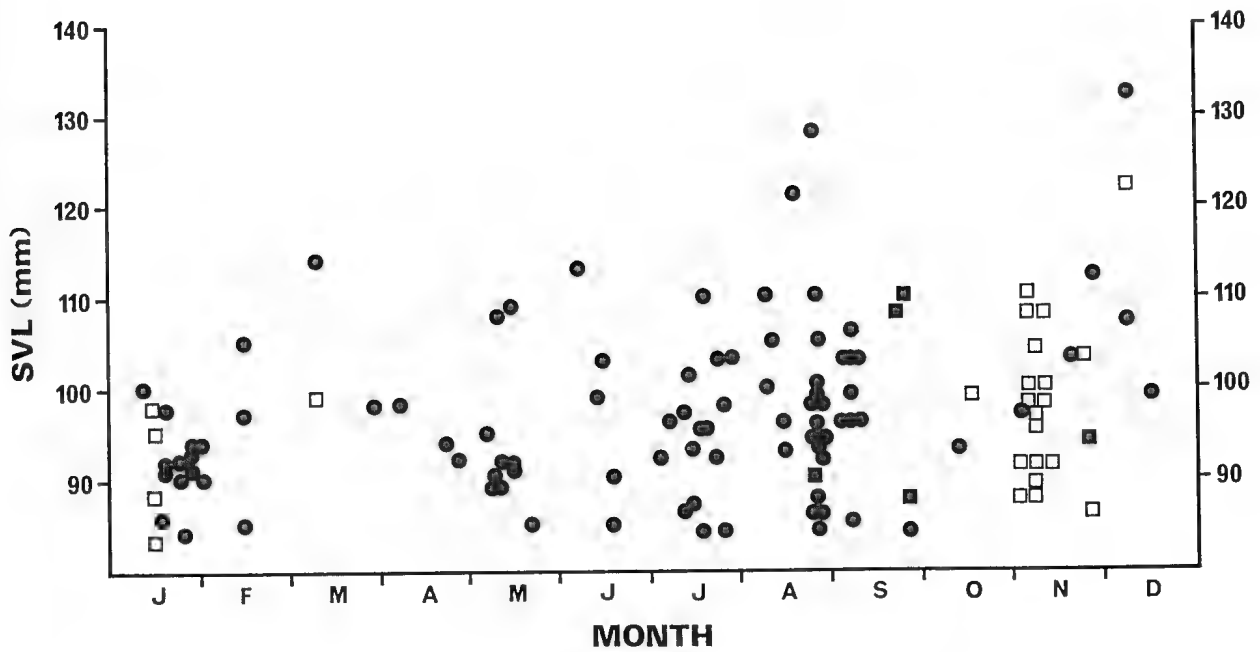


Fig. 21. Seasonal occurrence of non-vitellogenic follicles (dots), yolking ovarian follicles (squares) and oviducal embryos (open squares) in *Cyclodomorphus melanops melanops*.

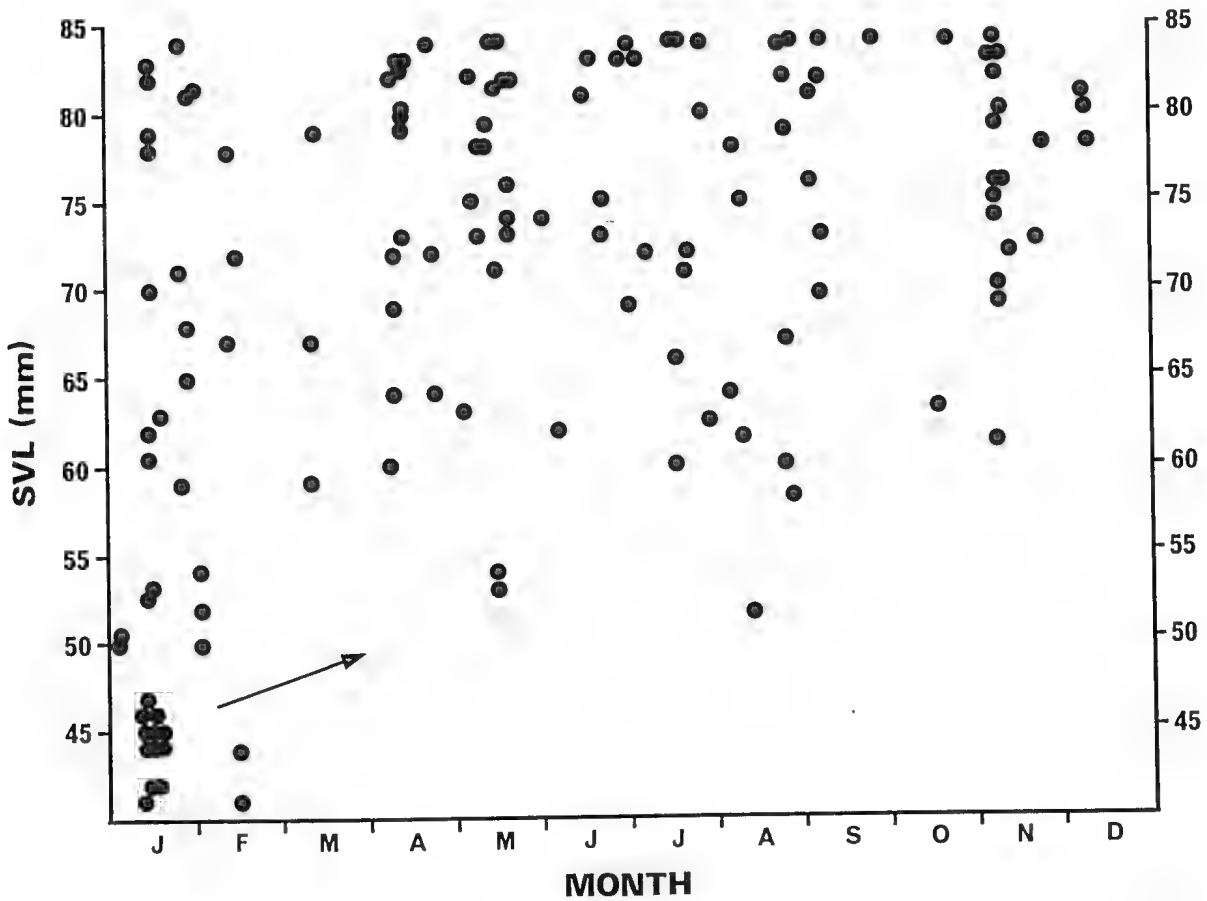


Fig. 22. Seasonal variation in SVL in immature *Cyclodomorphus melanops melanops*. Arrow indicates inferred growth of first year cohort.

Roadhouse; WAM R13862, "Mardie"; R14277, Dolphin Island, Dampier Archipelago; R22933, Karratha; R25631, 17 miles east "Yarraloola"; R25641, 10 miles east "Yarraloola"; R25647, R25656, 16 miles east "Yarraloola"; R25651-52, 10 miles north "Peedamulla"; R25653, 10 miles west "Peedamulla"; R25659-60, 15 miles east "Yarraloola"; R61543-45, R96785, Myaree Pool; R61581, Jundalaya Hill, 15 km west "Nanutarra"; R61594-97, Cattle Pool, Cane River; R68332, Pannawonica; R71487-89, 6 km south-east "Manberry"; R71592-93, "Mt Cahill" Outcamp, 16 km south-east "Mardathuna"; R76421, Harding River, c. 52 km south-east Karratha; R78944, Harding River, 32 km south-east Karratha; R80176, R81306, 2 km south Barradale Roadhouse; R80247, 4 km west Barradale Roadhouse; R80253, 9.5 km north-west Barradale Roadhouse; R80739, 1 km south Nanutarra Roadhouse; R84263, Burrup Peninsula; R85040, 11 km north-north-west "Uaroo"; R91137, Harding River Dam; R94389-91, 3 km north-north-west "Cane River". **LOWER ASHBURTON:** AM R15482, WAM R25355, Kookhabinna Gorge, Barlee Range; AM R15484-87, "Ullawarra"; WAM R25265, 13 miles north-west "Ullawarra"; R84069, "Glenflorrie" HS. **MILLSTREAM:** SAM R4569, R4573, WAM R20170-74, R20176-77, R20182, R20186, R94607, "Millstream"; SAM R4570, WAM R20175, 28 miles south "Kangiangi"; SAM R4571, WAM R20179, R20185, 3 miles east Mt Ulric; SAM R4574, Mt Ulric Gorge; SAM R4582-83, Fortescue Creek, "Millstream"; SAM R4584, WAM R20178, "Tambrey"; SAM R4585, WAM R20184, 5 miles north "Kangiangi"; WAM R20181, "Coolawanyah" aerodrome; R51717, 100 km north-west Wittenoom; R74915-18, "Mt Brockman"; R81366-70, 3 km east "Millstream"; R88667, 2 km north-east "Millstream". **HAMERSLEY:** SAM R4572, R4576, WAM R20183, Asbestos Creek; WAM R13090, R13327, R27751, R82718, "Woodstock"; R13322, Dale Gorge, Wittenoom; R34731, Kyan Pool, "Hooley"; R37071, 6 miles north Wittenoom; R37086, Hancock Gorge, 9 miles south Wittenoom; R54381, R55908-09, R56837, R69767-68, Marandoo; R55987, 3 km west East Ore Body, Paraburdoo; R55988, Paraburdoo; R69681-82, c. 10 km east Marandoo; R69713-15, 4 km west Marandoo; R69736, north-east side Mt Bruce; R69748, R69766, Coppin Pool, Turee Creek; R73564, nr Barnett Creek, 30 km north-north-west Tom Price; R73745, R73750, 22 km west Tom Price; R74882, 10 km south-south-east Mt Bruce; R74897, 10 km south-west "Rocklea"; R76538, 20 km north-west Tom Price; R76555, 24 km north-north-west Tom Price; R76558, 4 km west Tom Price; R76562, 4 km north-north-west Tom Price; R80798, Milli Milli Spring, Hamersley Range. **UPPER ASHBURTON:** AM R100679, WAM R23953-64, R25188-92, Kumarina; WAM R22701, "Mulgul"; R22804-05, Nichol Spring, 30 miles south "Mt Vernon" on Ethel Creek; R25235, 18 miles north-west "Mt Vernon". **MOUNT NEWMAN:** AM R76228, camp on Weeli Wolli Creek, nr "Marillana"; WAM R25176, R29742, Mt Newman; R27756, "Poonda", 28 miles south-west "Roy Hill"; R67898, 34 km south-east Mt Meharry; R71651, 21 km west-south-west "Marillana"; R73149, 24 km south-west "Marillana"; R73939, Weeli Wolli Spring; R91660, 38 km west-north-west Newman. **TALAWANA:** WAM R19850, "Balfour Downs"; R25187, 20 miles east Jigalong; R39129-30, "Talawana"; R42232-33, Junction Well, Oakover River. **OAKOVER:** WAM R13198, R13239, R83170-71, Burramine; R13237, R83162-66, Budjan Creek, 8 km south "Corunna Downs"; R13238, R83167-69, Ripon Hills; R13242, R84988-92, Mosquito Creek-Eastern Creek; R36337, 10 miles south Nullagine; R45761-62, 3 miles south-east "Mt Edgar"; R51723, 24 km north "Roy Hill"; R58962-63, 65 km north "Roy Hill"; R63109, 15 km c. 125° Nullagine; R63119-20, 2 km 156°

Italy Bore; R63124, R74087, Rove Hills Mine; R63143-46, Woody Woody Mine; R63158, 5 km 336° Skull Spring; R68360-62, between Nullagine and "Roy Hill"; R73941, 16 km south-east Nullagine; R73942-44, R73972-91, 5 km east-north-east Kurrana Well; R74074-79, 7 km east-north-east Kurrana Well; R74090-92, Skull Spring, Davis River; R74097-99, 16 km south Upper Carawine Pool; R83881-84, "Warrawagine"; R94679, Carawine Gorge.

**GREAT SANDY DESERT, WA:** WAM R15842, 17 miles north Weld Spring, Canning Stock Route; R53634, south end Carnarvon Range; R63459, Tobin Lake; R63539, 2 km 36° Murguga Well (Canning Stock Route No. 39); R63771, 1 km north Talbot Soak; R63947, 12 km north-north-east Well 29, Canning Stock Route; R94712, "Glenayle".

**CENTRALIAN:** AM R17257-59, 20 miles east Piltadi, Mann Range, SA; R26399-401, nr Peterman Range, 61 miles from WA border, NT; R52074-76, Stuart Hwy, 18 miles south-west Barrow Creek, NT; R52077, Barrow Creek, NT; CAWC R835, Ayer's Rock, NT; R1017, nr Mereenie, Well No. 1; CAWC R1105, "McLaren Creek", NT; NTM R1706, Armstrong Creek, 100 km west Ayer's Rock, NT; NTM R12109-10, 7 km south-west Bull Creek Bore, Davenport Range, NT; SAM R343, Central Australia; R25882, north-west tip Cavenagh Range, 1 km south-east Linton Bore, WA; R29549, Mt Crombie, SA; WAM R15157, 8 miles south-south-east Warburton Range Mission, WA; R16554, 20 miles south-west Warburton Range Mission, WA; R20708-09, 11 miles south-west Muggan Rock Hole, WA; R20736, Cavenagh Range, WA; R20752, 23 miles south-east Giles, WA; R20790, 27 miles west-north-west Mt Olga, NT; R20958-59, 28 miles west "Musgrave Park", SA; R20991, 9 miles west Cavenagh Range, WA; R20999, Mt Palgrave, Barrow Range, WA; R22176, 5 miles south Warburton Range Mission, WA; R24355, 6 miles south-west Barrow Creek, NT; R24362, 15 miles south-west Barrow Creek, NT; R28992, Jameson Range, WA; R40142, Davenport Range, NT; R46552-53, 6 miles south-west Nullye, WA; R60158, 62 km east Neale Junction, WA; R85667-68, R85670, 8 km west-north-west Point Salvation, WA.

*Cyclodomorphus melanops elongatus*  
(Werner, 1910)

Figs 23-28

*Lygosoma (Lygosoma) muelleri* Peters, 1878: 191.

*Lygosoma (Homolepida) branchiale elongatum* Werner, 1910: 479.

*Lygosoma (Homolepida) petersi* Sternfeld, 1919: 81. [*nom. nov. pro. Lygosoma muelleri*, at that time a junior homonym of *Scincus muelleri* Schlegel, 1839].

*Lygosoma (Homolepida) woodjonesii* Proctor, 1923: 80.

**Diagnosis.** *Cyclodomorphus m. elongatus* differs from all other members of the *C. branchialis* species group in possessing a mode of 24 or more midbody scales, 61-85 paravertebral scales, 58-77 subcaudal scales, moderately large, open ear aperture, usually  $\beta$ -temporal configuration, and mid grey-brown to dark olive green dorsum without dark spots.

**Description.** Prefrontals rarely in narrow to moderate contact (1.1%,  $n = 378$ ), fused to frontonasal unilaterally

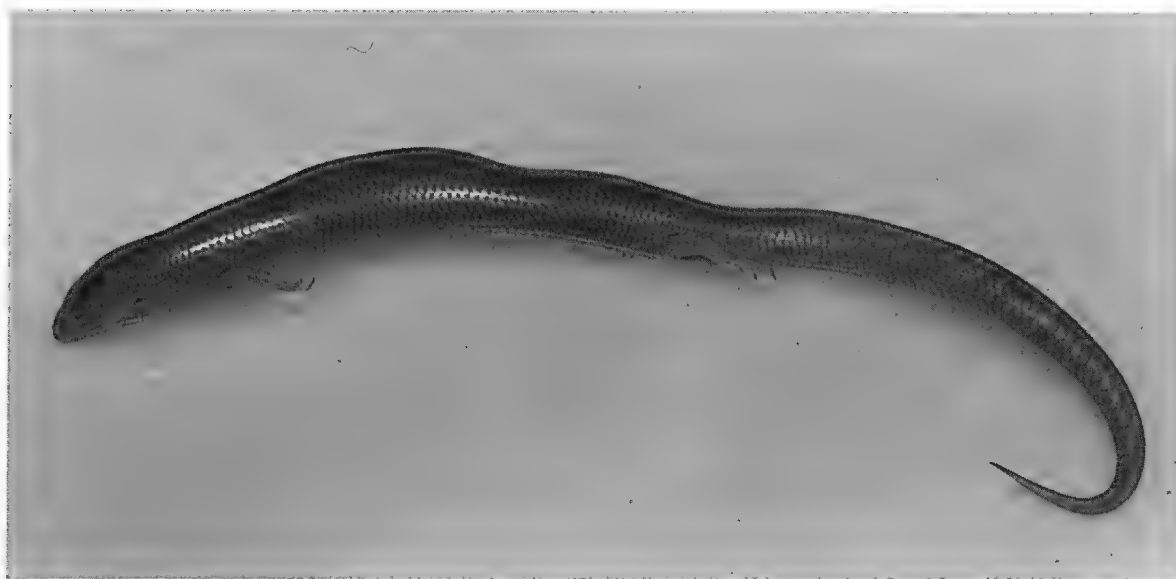


Fig. 23. Lectotype of *Lygosoma muelleri* Peters (ZMB 9373).

(0.3%) or bilaterally (0.3%) or fused to frontal unilaterally (0.3%); parietals completely separated by interparietal (94.4%,  $n = 372$ ), or in point to moderate contact caudally (5.6%); interparietal broadest rostrally, approximately  $\frac{2}{3}$ – $\frac{9}{10}$  length and breadth of frontal; transversely enlarged nuchals 0–5 on each side ( $\bar{x} = 2.9$ ,  $SD = 0.70$ ,  $n = 753$ ), usually three (64.7%); loreals rarely three unilaterally (1.1%,  $n = 366$ ) or bilaterally (0.3%), one unilaterally (1.1%) or bilaterally (0.6%) or absent unilaterally (0.3%); supraoculars rarely four unilaterally (0.5%,  $n = 377$ ), two unilaterally (1.3%) or one unilaterally (0.3%), reduction to two due to partial fusion of first and second ( $n = 1$ ) or fusion of second and third ( $n = 2$ ); supraciliaries 4–8 ( $\bar{x} = 6.0$ ,  $SD = 0.38$ ,  $n = 752$ ), usually six (89.2%), first and last largest, third-last usually projecting between second and third supraocular, remainder moderate, subequal; presuboculars rarely three unilaterally (0.3%,  $n = 354$ ) or one unilaterally (0.3%); postsuboculars 2–4 ( $\bar{x} = 3.4$ ,  $SD = 0.51$ ,  $n = 753$ ), usually three (60.2%); upper palpebrals 7–11 ( $\bar{x} = 8.7$ ,  $SD = 0.88$ ,  $n = 348$ ); lower palpebrals 8–12 ( $\bar{x} = 9.7$ ,  $SD = 0.87$ ,  $n = 348$ ); secondary temporals usually in  $\beta$ -configuration (88.2%,  $n = 768$ ), rarely in  $\alpha$ -configuration (11.8%); supralabials 6–9 ( $\bar{x} = 7.2$ ,  $SD = 0.44$ ,  $n = 747$ ), usually seven (76.8%), usually third-last (99.1%) below centre of eye, separating pre- and postsuboculars, rarely fourth last (0.4%) or second last (0.5%); infralabials 5–8 ( $\bar{x} = 6.2$ ,  $SD = 0.43$ ,  $n = 750$ ), usually six (80.4%); usually first two (94.5%,  $n = 752$ ), rarely first three (4.8%) or first (0.7%) infralabials contacting postmental; ear moderate, oval, usually subequal in height to eye, with 0–3 ( $\bar{x} = 1.09$ ,  $SD = 0.33$ ,  $n = 708$ ), usually one (89.0%), small to large rounded lobules along rostral margin.

Body scales in 22–29 ( $\bar{x} = 25.1$ ,  $SD = 1.27$ ,  $n = 385$ ), usually 24 (42.1%) or more (55.3%), longitudinal rows at midbody; scales in paravertebral rows moderately broader than adjacent lateral dorsal scales, 61–85 ( $\bar{x} =$

72.1,  $SD = 4.41$ ,  $n = 386$ ); subcaudal scales 58–77 ( $\bar{x} = 68.2$ ,  $SD = 3.90$ ,  $n = 173$ ); lamellae below fourth toe 9–17 ( $\bar{x} = 12.6$ ,  $SD = 1.27$ ,  $n = 699$ ), each with a narrow to broad light to mid-brown callus.

SVL 41–125 mm ( $n = 401$ ); AGL/SVL 50.0–76.3% ( $\bar{x} = 63.6\%$ ,  $n = 389$ ); TL/SVL 69.1–110.3% ( $\bar{x} = 93.9\%$ ,  $n = 182$ ); FLL/SVL 10.9–23.5% ( $\bar{x} = 16.6\%$ ,  $n = 397$ ); HLL/SVL 15.3–29.3% ( $\bar{x} = 21.5\%$ ,  $n = 393$ ); FLL/HLL 66.7–92.0% ( $\bar{x} = 77.1\%$ ,  $n = 392$ ); HL/SVL 12.3–22.5% ( $\bar{x} = 15.5\%$ ,  $n = 392$ ); HW/HL 60.8–85.1% ( $\bar{x} = 72.7\%$ ,  $n = 393$ ); HD/HL 45.9–67.6% ( $\bar{x} = 55.9\%$ ,  $n = 392$ ).

Presacral vertebrae 38–44 ( $\bar{x} = 41.7$ ,  $SD = 1.23$ ,  $n = 115$ ); postsacral vertebrae 35–45 ( $\bar{x} = 39.4$ ,  $SD = 1.90$ ,  $n = 42$ ); phalangeal formula for manus and pes 2.3.4.4.3.

**Allometry.** With respect to SVL, AGL and TL showed positive allometry, while limb lengths and HL showed negative allometry. With respect to HL, both HW and HD showed positive allometry (Table 10).

**Coloration (in preservative).** Dorsum mid grey-brown to dark olive green, venter cream. Body scales usually with slightly darker edges, forming an obscure dark reticulum. Soles cream, with light grey to dark grey-brown tubercles and calli. Upper lips and sides of neck usually cream, with grey margins to scales.

Juveniles, and occasional subadults, as for adults, but with a single cream to pale yellow fleck in most dorsal and lateral body and tail scales, aligned laterally to form vertical bars.

**Coloration (in life).** AM R111032–33 were light greyish-green above, becoming cream with a greenish tinge ventrolaterally and cream ventrally; greenish edges to ventral scales forming a reticulum; tail and vent with a very weak yellowish flush; head greenish-grey, slightly darker than body dorsum; yellowish tint around ear;

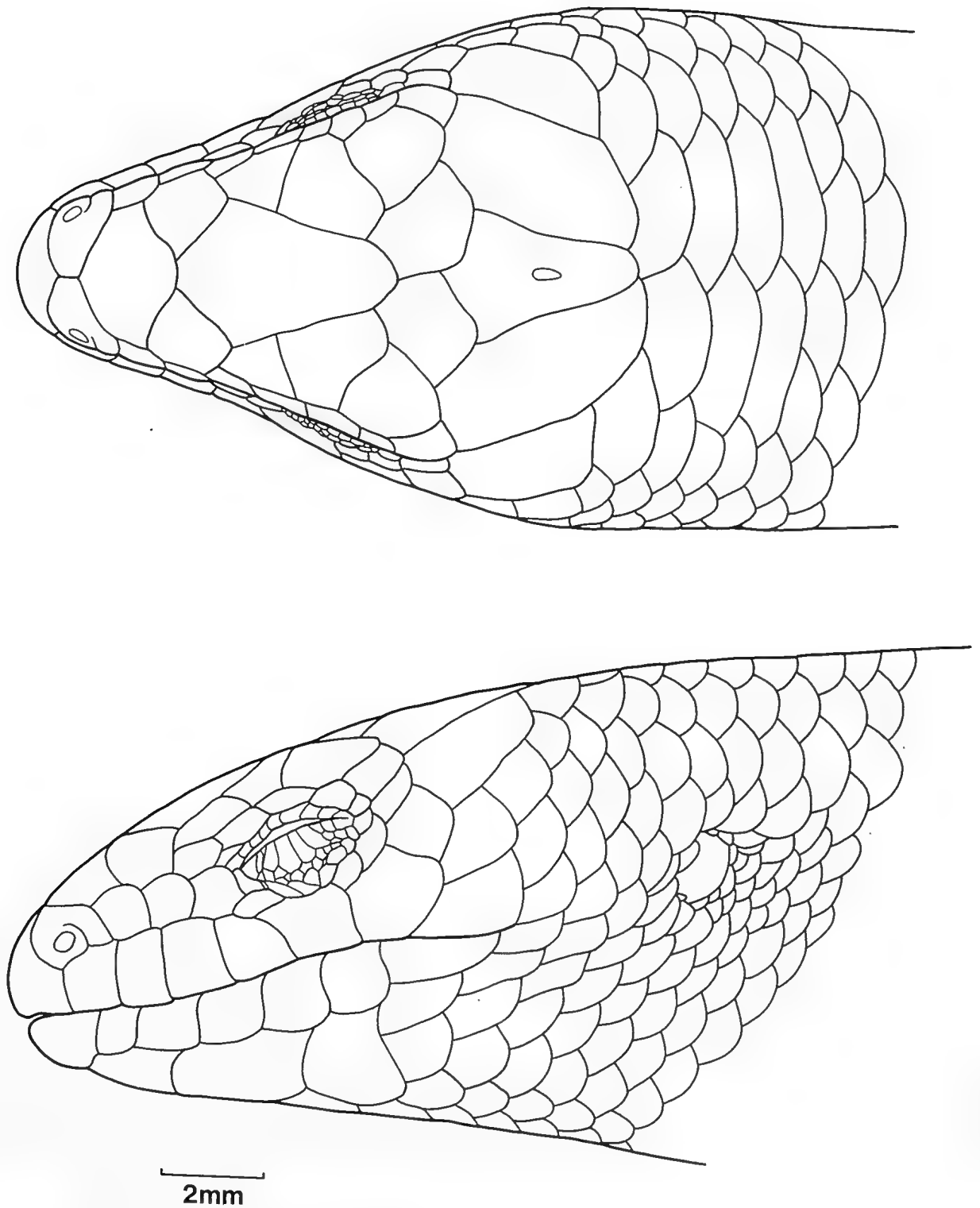


Fig. 24. Head shields of lectotype of *Lygosoma muelleri*.



Fig. 25. Holotype of *Lygosoma (Homolepida) branchiale elongatum* Werner (ZMH R03961).

palms cream; pupil black; mouth lining pink.

Both specimens, as well as AM R107954–56, R121029 and two live specimens from 12.5 km north “Coombah”, had irides orange and tongue dark blue-black. In AM R105443 and R105446, the irides were orange, tongue blue-brown and venter green-white, with an orange flush over the belly and tail base (Shea & Wells, 1985).

**Sexual dimorphism.** Mature-sized males (SVL 71–111 mm,  $\bar{x}$  = 87.2 mm, SD = 9.15,  $n$  = 134) were significantly smaller than mature-sized females (SVL 75–122 mm,  $\bar{x}$  = 93.3 mm, SD = 9.82,  $n$  = 148; Mann-Whitney U test,  $z$  = 5.015\*\*\*). Males additionally had shorter bodies, but longer tails, limbs and heads than females at a given SVL (Table 11).

Females had a greater number of paravertebral scales (61–85,  $\bar{x}$  = 73.5, SD = 4.41,  $n$  = 174 vs 61–81,  $\bar{x}$  = 70.7, SD = 4.22,  $n$  = 140;  $t_{312}$  = 5.66\*\*\*) and subcaudal scales (61–77,  $\bar{x}$  = 68.8, SD = 3.41,  $n$  = 71 vs 60–76,  $\bar{x}$  = 67.3, SD = 3.41,  $n$  = 72;  $t_{141}$  = 2.55\*) than males.

No significant differences were found between sexes in mean number of midbody scales, subdigital lamellae, supralabials, infralabials, supraciliaries, postsuboculars, nuchals, upper palpebrals or lower palpebrals.

**Distribution.** *Cyclodomorphus m. elongatus* occurs through the *Triodia* deserts and semiarid areas of southern Australia (Fig. 14), from 1 km west Lake Cronin and 70 km north Bullfinch, WA in the west, through the Western Australian Goldfields, Great Victoria Desert, northern Eyre Peninsula, Gawler and Flinders Ranges to 12.5 km north “Coombah”, NSW in the east,

with outlying populations in western Queensland (“Diamantina Lakes” north to 41 km south Dajarra, and south-east to 5 km west “Fermoy”), central Australia (Blackstone Mining Camp and Bell Rock Range, WA in the south-west to “Ti Tree”, NT in the north-east) and Nuyts Archipelago, SA (St Francis, Fenellon and Lacy Is.).

Four old specimens (SAM R2728a–c, R2729) recorded from Flinders Island, SA (Hudson *et al.*, 1981) are not supported by recent collections from that island, and may have come from the Nuyts Archipelago, which population they most closely resemble. For the purposes of exploring geographic variation, however, the records are considered valid. A single record from Kangaroo Island (SAM R2730) is unsupported by subsequent collections from this herpetologically well-known island (Houston & Tyler, 1979) and is considered erroneous.

**Geographic variation.** For the purposes of describing geographic variation, the overall distribution of *C. m. elongatus* was divided into nine subpopulations, named, approximately from west to east, Boorabbin, Zanthus, Centralian, Ooldea, Nuyts, Eyre Peninsula, Flinders Island, Flinders Ranges, NSW and Queensland (Fig. 14). Statistically significant variation was present in all scalational characters assessed. In general, the most different populations were peripheral, particularly those on the eastern and northern periphery, with in many cases, greater numbers of scales in the eastern (Flinders Ranges, Queensland, NSW) populations.

Paravertebral scales. ANOVA:  $F_{9,373}$  = 33.056\*\*\*. Means ranged from 68.3 (Zanthus) to 77.7 (Flinders Ranges). A trend towards higher means in the east and

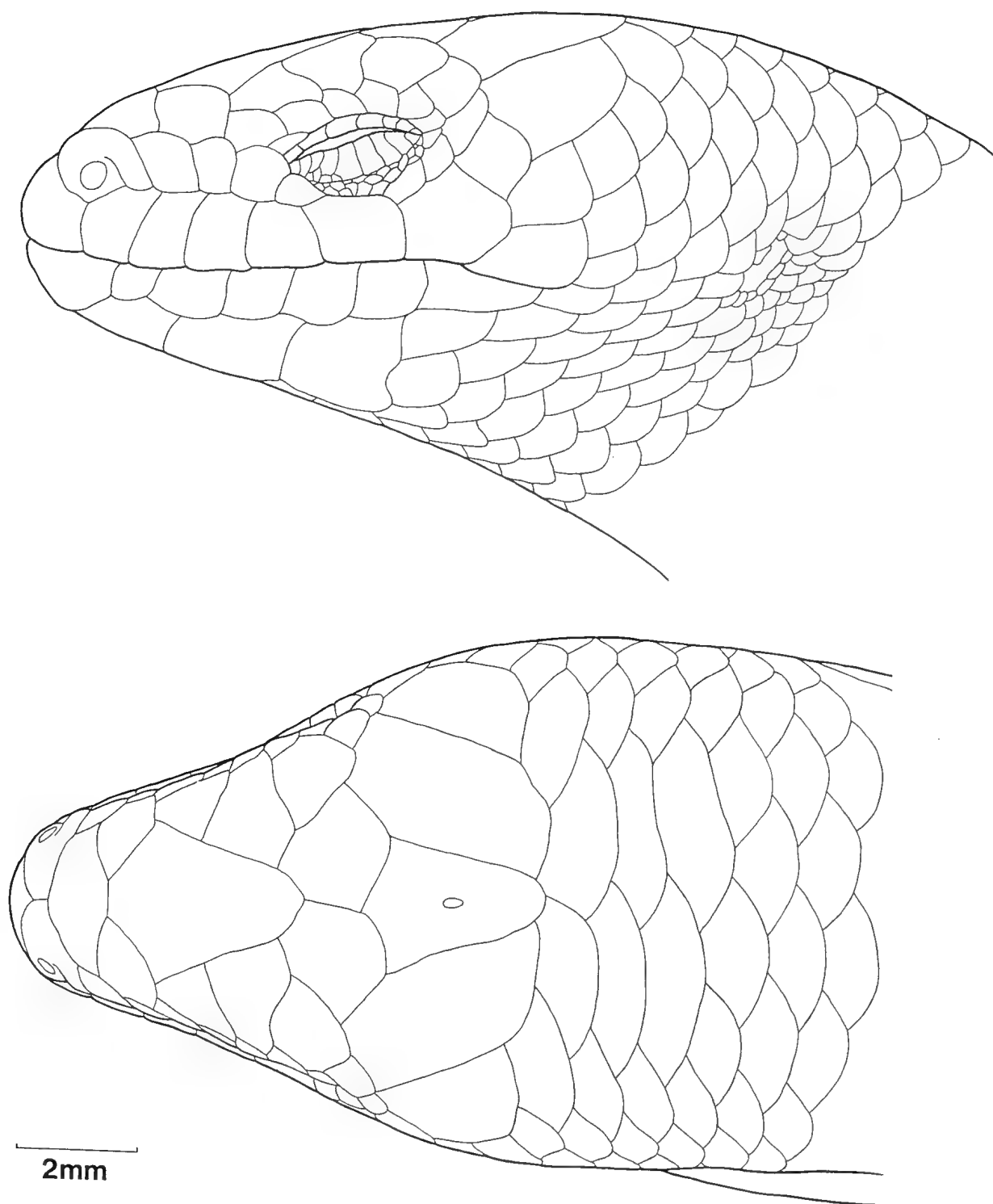


Fig. 26. Head shields of holotype of *Lygosoma (Homolepida) branchiale elongatum*.

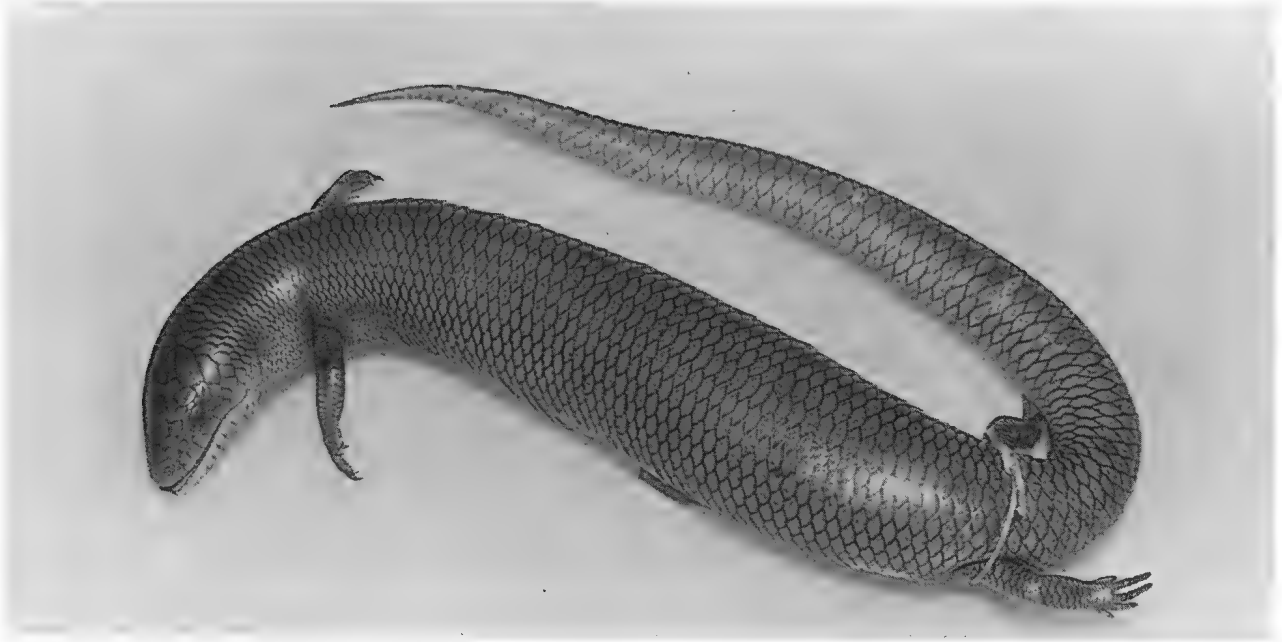


Fig. 27. Lectotype of *Lygosoma (Homolepida) woodjonesii* Proctor (BMNH 1946.8.17.97).

north was apparent, with the four highest means (Centralian, Flinders Ranges, NSW, Queensland;  $\bar{x}$ 's = 74.1–77.7) significantly different to many other populations, including the most geographically proximate populations (Centralian, Flinders Ranges, Queensland vs Boorabbin, Eyre Peninsula, Flinders Island, Ooldea and Zanthus; former two also vs Nuyts; NSW vs Boorabbin and Zanthus). Amongst the other populations, the only significant differences were between the three extreme means (Zanthus vs Eyre Peninsula and Nuyts;  $\bar{x}$ 's = 71.4–71.5).

Midbody scales. ANOVA:  $F_{9,373} = 18.239^{***}$ . Means ranged from 24.5 (Ooldea, Queensland) to 27.1 (NSW, Nuyts), with only the latter and the Centralian population having means greater than 25.0 and modes greater than 24 (26 in Centralian, 28 in NSW, Nuyts). These three populations, all peripheral, have significantly greater means than most other populations (all vs Boorabbin, Eyre Peninsula, Ooldea, Queensland and Zanthus; NSW and Nuyts also vs Centralian and Flinders Ranges).

Subcaudal scales. ANOVA:  $F_{8,162} = 15.747^{***}$ . No data were available for the Flinders Island sample. Means ranged from 65.3 (Boorabbin) to 74.4 (Queensland), with only the latter and Flinders Ranges ( $\bar{x} = 71.8$ ) above 69.3. A general trend for higher means in the east and north of the distribution was apparent, with the Queensland mean significantly greater than all but the Flinders Ranges mean, while the Eyre Peninsula, Zanthus and Boorabbin means, the three lowest ( $\bar{x}$ 's = 65.3–66.7), were significantly lower than the Queensland, Flinders Ranges and Centralian means.

Subdigital lamellae. ANOVA:  $F_{9,684} = 46.196^{***}$ . Means varied from 11.6 (Eyre Peninsula) to 14.7 (Queensland), although only the latter mean was greater than 13.2. The Queensland mean was significantly greater than all other means, while the three lowest means (Ooldea,

Flinders Ranges, Eyre Peninsula,  $\bar{x}$ 's = 11.6–12.2), all from the central part of the subspecies' distribution, had significantly lower means than most other populations, including those immediately adjacent (all vs NSW, Nuyts, Queensland and Zanthus; Flinders Ranges and Eyre Peninsula also vs Centralian; Eyre Peninsula also vs Boorabbin).

Supralabials. ANOVA:  $F_{9,735} = 11.687^{***}$ . Means ranged from 7.1 (Boorabbin, Queensland) to 7.9 (NSW), although only the latter and Flinders Ranges ( $\bar{x} = 7.7$ ) had means above 7.4 and modes other than seven. These two high means were significantly different to most other populations (both vs Boorabbin, Centralian, Eyre Peninsula, Ooldea, Queensland and Zanthus; NSW also vs Nuyts). The only significant difference between other populations was between Nuyts ( $\bar{x} = 7.4$ ) and Queensland.

Infralabials. ANOVA:  $F_{9,736} = 8.404^{***}$ . Most populations had mode six and means of 6.0 (Boorabbin, Zanthus) to 6.4 (Flinders Island), with significant differences between only Boorabbin and Centralian, and Zanthus and Centralian and Queensland. The NSW population ( $\bar{x} = 6.8$ , mode seven) had a significantly greater mean than all but the Flinders Island population.

Supraciliaries. ANOVA:  $F_{9,736} = 4.211^{***}$ . Six supraciliaries was modal for all populations. Means ranged from 5.9 (Boorabbin) to 6.5 (Flinders Island), with only the latter mean and Flinders Ranges ( $\bar{x} = 6.3$ ) greater than 6.1. The Flinders Island and Flinders Ranges means were significantly different to the Centralian, Zanthus and Boorabbin means, with the Flinders Island mean also different to the Ooldea and Eyre Peninsula means. The only other significant difference was between the Boorabbin and Queensland means. In no cases did these differences involve contiguous populations.

Postsuboculars. ANOVA:  $F_{9,737} = 12.129^{***}$ . Means



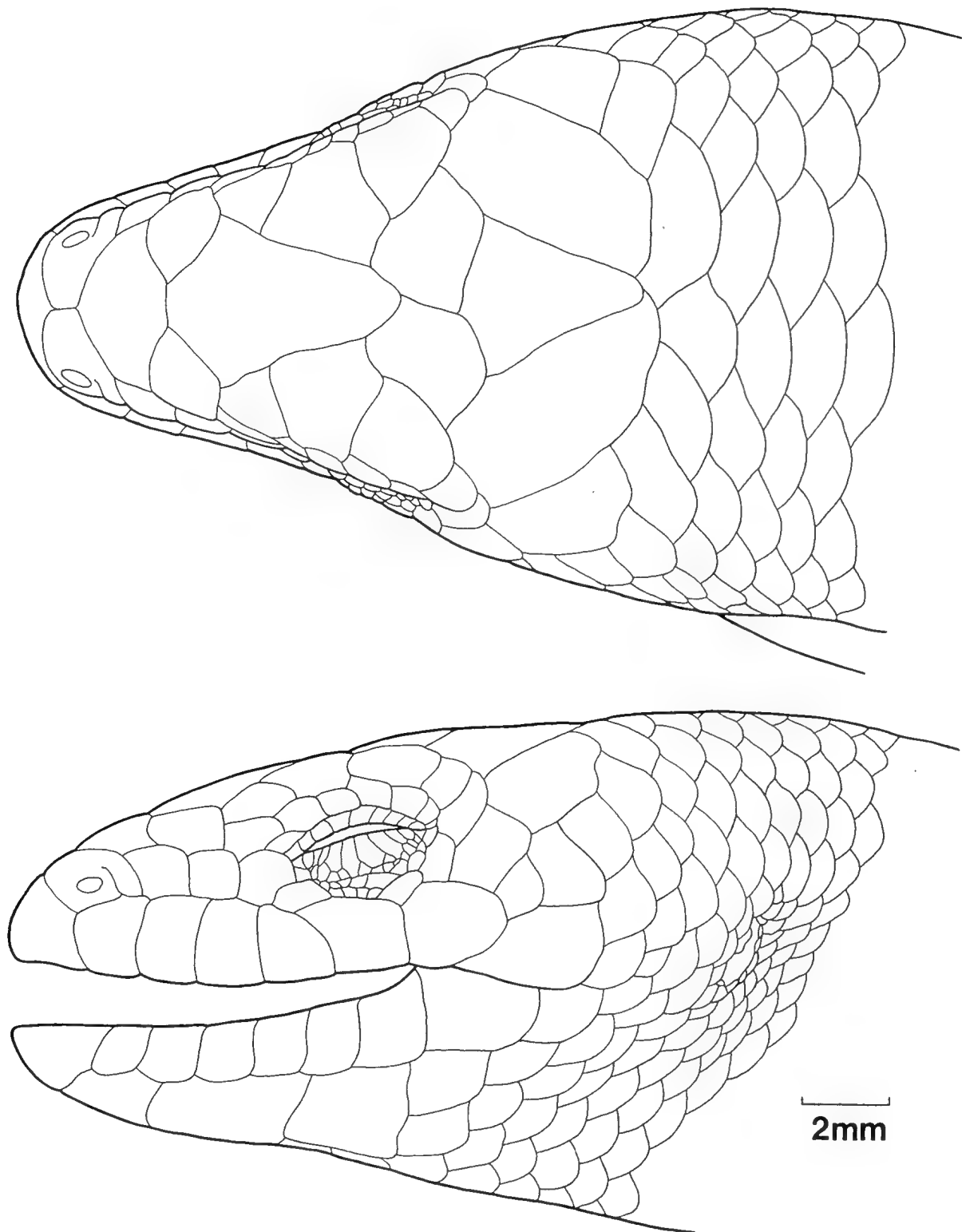


Fig. 28. Head shields of lectotype of *Lygosoma (Homolepida) woodjonesii*.

ranged from 3.1 (Boorabbin) to 3.8 (Flinders Island, Nuyts). In general, the easternmost populations (NSW, Queensland;  $\bar{x}$  = 3.7) and insular populations had greater means and modes (four in all) than elsewhere in the distribution (all *vs* Boorabbin, Zanthus and Centralian; Queensland and Nuyts also *vs* Eyre Peninsula, Ooldea).

Nuchals. ANOVA:  $F_{9,740} = 9.732^{***}$ . All populations had mode three. Means ranged from 2.2 (NSW) to 3.4 (Queensland), although all other means were within the range 2.5–3.0. The two extreme values, both from populations at the extreme east of the distribution, were significantly different to most other means (Queensland *vs* Boorabbin, Centralian, Eyre Peninsula, Flinders Ranges, NSW, Nuyts and Zanthus; NSW *vs* Boorabbin, Centralian, Eyre Peninsula, Ooldea and Zanthus). The only significant differences elsewhere in the distribution were between Zanthus ( $\bar{x}$  = 3.0), and Eyre Peninsula and Nuyts ( $\bar{x}$ 's = 2.5–2.7).

Upper palpebrals. ANOVA:  $F_{9,335} = 8.543^{***}$ . Means ranged from 8.5 (Boorabbin, Zanthus, Eyre Peninsula, Flinders Island and Flinders Ranges) to 10.0 (Queensland), with only the latter mean above 8.9. The high Queensland mean was significantly different to all other means.

Lower palpebrals. ANOVA:  $F_{9,335} = 6.833^{***}$ . Means ranged from 9.3 (Boorabbin) to 10.6 (Queensland). Only the latter population and Nuyts ( $\bar{x}$  = 10.2) had means greater than 10.0, and were significantly different to other populations (both *vs* Eyre Peninsula, Zanthus and Boorabbin; Queensland also *vs* Centralian and Flinders Ranges).

Secondary temporals. Queensland had a much higher proportion of the  $\alpha$ -configuration (41:17) than the other populations (pooled, 17:660;  $\chi^2_1 = 207.0^{***}$ ).

Snout-vent length. The Queensland population attains a larger size than other populations (mature-sized males: SVL 98–111 mm,  $\bar{x}$  = 105.3 mm,  $n$  = 6 *vs* 71–107 mm,  $\bar{x}$  = 86.4 mm,  $n$  = 128, Mann-Whitney U test,  $z$  = 3.84<sup>\*\*\*</sup>; mature-sized females: SVL 98–122 mm,  $\bar{x}$  = 108.8 mm,  $n$  = 5 *vs* 75–119 mm,  $\bar{x}$  = 92.8 mm,  $n$  = 143, Mann-Whitney U test,  $z$  = 3.05<sup>\*\*</sup>).

Coloration. Queensland and Nuyts Archipelago specimens generally had paler grey-brown dorsums, while southern mainland (Boorabbin, Zanthus, Ooldea, Eyre Peninsula, NSW) specimens generally had dark olive-green dorsums.

**Type material.** *Lygosoma muelleri* Peters, 1878 was described from two specimens from South Australia, presented by Baron Ferdinand von Müller to the Royal Cabinet of Stuttgart, and has usually been placed in the synonymy of *C. casuarinae*, most recently by Cogger *et al.* (1983), who list ZMB 9373 as "syntypes". We have examined a single specimen bearing this number (Fig. 23, 24), corresponding well to the type description, and find it typical of the form described here. Accordingly, we designate this specimen lectotype. This specimen has the locality Murray River, and is presumably from the population near Renmark. The specimen has the following combination of characters: supraciliaries 5/6;

postsuboculars three; nuchals 3/4; supralabials seven; infralabials six;  $\beta$ -configuration of secondary temporals; upper palpebrals nine; lower palpebrals ten; midbody scales 24; paravertebral scales 69; subcaudal scales 70; subdigital lamellae 11/12; SVL 96 mm; AGL 63 mm; TL 96 mm; FLL 13.5 mm; HLL 17.5 mm; HL 13.1 mm; HW 9.8 mm; HD 7.6 mm.

*Lygosoma muelleri* Peters is a junior subjective homonym of *Scincus muelleri* Schlegel, 1839 [= *Sphenomorphus muelleri*, *vide* Loveridge, 1948], placed in *Lygosoma* between 1839 (Duméril & Bibron, 1839) and 1930 (de Jong, 1930). Sternfeld (1919, 1925) proposed the replacement name *Lygosoma (Homolepida) petersi* for *L. muelleri*, though basing his redescription on material from Hermannsburg, NT. Subsequent authors (Loveridge, 1934, 1948; Mitchell, 1950; Worrell, 1963) inexplicably reduced *L. petersi* to a central Australian subspecies of the mesic south-eastern species *C. casuarinae*, although possibly on the basis of Boulenger's (1887) earlier synonymy.

*Lygosoma (Homolepida) branchiale* var. *elongatum* Werner 1910 was erected, almost parenthetically, on the basis of a single specimen collected by Michaelsen and Hartmeyer at Boorabbin on 3 July 1905, the only specimen of the *C. branchialis* complex collected by their expedition. Cogger *et al.* (1983) did not locate the holotype. Of the collections known to house reptile material from the Michaelsen and Hartmeyer collection (NHMW, SMF, ZMB, ZMH; Cogger *et al.*, 1983), there are no specimens of *C. melanops* in the former three with appropriate data to be the holotype. A single ZMH specimen (R03961; formerly 3500), not identified as the type (and hence surviving the Second World War bombing that destroyed the ZMH type collections) bears printed Michaelsen and Hartmeyer labels corresponding to the type description, as well as a handwritten label giving Werner's determination of the specimen as *Lygosoma (Homolepida) branchiale* (H.-W. Koepcke, pers. comm.) and is here presumed to be the holotype. This specimen (Figs 25, 26) has the following combination of characters: supraciliaries six; postsuboculars three; nuchals three; supralabials seven; infralabials six; upper palpebrals seven; lower palpebrals nine;  $\beta$ -configuration of secondary temporals; midbody scales 24; paravertebral scales 72; subcaudal scales 60; subdigital lamellae 15/14; SVL 76.5 mm; AGL 51 mm; AGL 51 mm; TL 61.5 mm (distal part of tail broken off but retained); FLL 12 mm; HLL 16.5 mm; HL 12.0 mm; HW 8.2 mm; HD 6.5 mm. The measurements correspond reasonably closely to those provided by Werner (1910): SVL 80 mm; TL 64 mm; FLL 14 mm; HLL 15 mm; HL 14 mm; HW 9 mm. Differences are probably due to differences in reference points for making measurements, and possibly to subsequent shrinkage of the specimen.

*Lygosoma (Homolepida) woodjonesii* Proctor, 1923 was described from three syntypes from St Francis Island in the Nuyts Archipelago, collected by F. Wood-Jones, and distinguished from other members of the *C. branchialis* species group primarily on the basis of a higher midbody scale count (28 *vs* 26). However, of the

three syntypes (BMNH 1946.8.17.97–99) the adult female mentioned by Proctor (BMNH 1946.8.17.97) has 29 midbody scales, while the other two have 26. Wells & Wellington (1985) nominate BMNH 1946.7.17.97 as lectotype. This specimen (Figs 27,28), a gravid female with three full-term embryos, has the following combination of characters: supraciliaries 6/7; postsuboculars four; nuchals 0/1; supralabials 7/8; infralabials 7/6;  $\beta$ -configuration of secondary temporals; upper palpebrals nine; lower palpebrals eleven; paravertebral scales 74; tail regenerated; subdigital lamellae 13; presacral vertebrae 39; SVL 111 mm; AGL 73; FLL 17.5 mm; HLL 22 mm; HL 16.0 mm; HW 11.4 mm; HD 9.7 mm.

The two paralectotypes have (counts for BMNH 1946.8.17.98 first) supraciliaries six, 6/7; postsuboculars four, 4/3; nuchals 2/3, 3/2; supralabials eight, 7/8; infralabials 6/7, six;  $\alpha$ - and  $\beta$ -configuration of secondary temporals; upper palpebrals eight, nine; lower palpebrals 11; paravertebral scales 69; subcaudal scales 66, 70; subdigital lamellae 12/13, 12/11; presacral vertebrae 40; postsacral vertebrae 38, 40; SVL 84.5, 82 mm, AGL 52, 51 mm, TL 77, 82.5 mm, FLL 17.5, 16 mm, HLL 22, 19.5 mm, HL 13.4, 13.2 mm, HW 9.6, 9.5 mm, HD 8.1, 7.6 mm.

**Comparison with other taxa.** Recognition of *C. m. elongatus* as distinct from *C. m. melanops* is based largely on the occurrence of both forms in central Australia. To the east of the Stuart Highway, the two forms are quite distinct, with the nominate subspecies, occurring in the west and north, having heavy dark spotting on a generally light yellow-brown to red-brown ground, and usually the  $\alpha$ -configuration of the lower secondary temporals, while *C. m. elongatus*, in the east and south, has an immaculate dark olive-green to olive-brown dorsum and the  $\beta$ -configuration. The two forms appear to be nowhere syntopic, yet approach to within 36 km in the north (Mereenie Well No. 1 vs No. 6) and approximately 45 km in the west (Blackstone Mining Camp vs Cavenagh Range). The large series from Erliwunyawunya Rockhole is exclusively of the *elongatus* form, while all three specimens from 20 miles east of Piltadi, in the Mann Ranges, are typical of nominal *melanops*. Only two specimens (WAM R20858–59, 28 miles west “Musgrave Park”) appear to combine the characters of the two races, being pale with numerous dark spots, yet both having the  $\beta$ -configuration. Additionally, Centralian *elongatus* have a higher number of midbody and paravertebral scales and a lower number of postsuboculars than Centralian *melanops* (midbody scale modes 26 (57.4%) vs 24 (65.6%); paravertebral scales 66–85,  $\bar{x}$  = 75.4 vs 64–76,  $\bar{x}$  = 70.2,  $t_{130}$  = 7.11\*\*\*; postsuboculars mode 3 (74.0%),  $\bar{x}$  = 3.2 vs mode 4 (78.5%),  $\bar{x}$  = 3.8;  $t_{267}$  = 9.36\*\*\*). However, to the east of the Stuart Highway, in the Davenport Ranges, the differences are less obvious, particularly in coloration. The four specimens from this area (CAWC R1105, NTM R12109–10, WAM R40142) have the  $\alpha$ -configuration, while the dorsum is pale grey, and the dark spotting

very reduced to absent, persisting longest on the venter. We identify these specimens as *C. m. melanops* on the basis of the temporal configuration, the presence of dark spots ventrally on some specimens, and their proximity to typical *C. m. melanops* around Barrow Creek. Further east again, the Queensland population is homogeneous in coloration, with dorsum grey-brown and lacking dorsal or ventral spots, yet has both temporal conditions. Indeed, our placement of the apparently isolated Queensland population with *C. m. elongatus* rather than the nominal subspecies is largely arbitrary, the uniform dorsal coloration, lack of dark flecks and high numbers of paravertebral scales tipping the balance in favour of *C. m. elongatus*. It is this apparent breakdown of the diagnostic characters in the extreme east that leads us to identify these two taxa as only subspecifically distinct, despite the absence of any synapomorphy linking the two taxa.

Outside of central Australia and Queensland, the differences in coloration and temporal configuration between the two subspecies are clearly defined, with all southern populations having a uniform dorsum, and almost always an immaculate venter, together with the  $\beta$ -configuration of the secondary temporals, and all north-western populations having the states described for *C. m. melanops*. Additionally, most *C. m. elongatus* populations have lower mean numbers of subcaudal scales ( $\bar{x}$ 's = 65.3–74.7, only Flinders and Queensland being greater than 69.2 vs  $\bar{x}$ 's = 69.6–78.1) and a shorter tail (Tables 5,10).

*Cyclodomorphus m. elongatus* differs from *C. branchialis* in having a uniform olive-green to olive-brown dorsum (vs cream to grey or reddish with dark spots, and solid dark “gill” markings on the sides of the neck). It also has generally more paravertebral (61–85 vs 62–70) and subcaudal (58–77 vs 57–64) scales and subdigital lamellae (9–17,  $\bar{x}$  = 12.6 vs 9–12,  $\bar{x}$  = 10.8). It is separated from *C. branchialis* by approximately 260 km (70 km north Bullfinch vs 56 km south-east Yalgoo).

*Cyclodomorphus m. elongatus* differs from *C. celatus* in coloration (uniform olive dorsum vs cream to grey with dark streaks, neck with several vertically-aligned series of dark longitudinal streaks) and in having a greater number of midbody scales (modes 24 or more for all populations vs 22), modally  $\beta$ - vs  $\alpha$ -configuration of secondary temporals, and a more open external ear, usually with a large, low, rounded rostral lobule. *Cyclodomorphus m. elongatus* is separated from *C. celatus* by approximately 360 km (70 km north Bullfinch vs the Jurien district), with much of the intervening area being unsuitable for either species, having hard soils and lacking hummock grasses.

In addition to the differences in body size, tail length, number of rostral ear lobules and interparietal shape differentiating *C. m. melanops* from *C. maximus* (see above), *C. m. elongatus* differs from *C. maximus* in having more midbody scales (mode 24 or 26 vs 22) and paravertebral scales (61–85,  $\bar{x}$  = 72.1 vs 61–67,  $\bar{x}$  = 64.4), fewer subdigital lamellae (9–17,  $\bar{x}$  = 12.6 vs 14–

17,  $\bar{x}$  = 15.3), and postsuboculars (modes 3 vs 4), modally  $\beta$ - vs  $\alpha$ -configuration of secondary temporals, a slightly deeper head (Tables 4,10), and immaculate olive-green to grey dorsum (vs red-brown with pale spots, and a dark circumocular ring).

**Habitat.** Mainland populations of *C. m. elongatus* appear to be primarily *Triodia* inhabitants (White, 1976; Dell & How, 1984, 1985; Shea & Wells, 1985). Of 164 specimens for which microhabitat is recorded, 154 (93.9%) were taken in or under *Triodia* or unidentified "spinifex", and a further 32 specimens were taken from unspecified microhabitats in *Triodia*-dominated habitats. Of the ten specimens not collected from *Triodia*, four (WAM R55362, R71174, R72387–88) were taken in or under spoil, three (WAM R72287–89) under *Casuarina* leaf litter, and one each in sedges (WAM R78775), in leaf litter on stony soil (WAM R64759) and under litter (WAM R65465).

The majority of specimens from southern mainland populations come from mallee-*Triodia* habitats on various soil types, although a number of other vegetation associations are also inhabited.

The Boorabbin population inhabits mallee-*Triodia* and eucalypt woodland/*Triodia* formations ( $n = 1$ ; WAM R64760: "very open tree mallee over spinifex"; WAM R64786: "open eucalypts over shrubland over spinifex on red earth"; WAM R71174: "sparse eucalypt woodland on white-red loamy sand"; WAM R78679: "*Eucalyptus formanii*, *E. lesouefii* and *E. campaspe* over *Triodia* on yellow sand"; WAM R78721: "open eucalypt woodland over mallee over spinifex and shrubs"), mallee heath habitats ( $n = 3$ ), *Acacia/Triodia* and other *Acacia* associations ( $n = 1$ ; WAM R71863, R71866, R78813: "*Acacia* shrubland over spinifex"; WAM R78723: "*Acacia* shrubland near granite outcrop"; WAM R78775: "open sedges and grasses on granitic soils, some *Acacia* to 3m"), *Callitris* heath ( $n = 5$ ) and a variety of intermediate habitats (WAM R64751, R64758: "mallee over mulga, other shrubs and spinifex on red earth"; WAM R64759: "open tree mallee over scrub *Acacia* over open low grass on stony soil of range outwash"; WAM R70902: "base of red sandy dune with low woodland of *Casuarina* and mulga over sparse scrub and herbs"; WAM R72720: "mallee/mulga/spinifex"; WAM R78664: "*Eucalyptus campaspe*, *Acacia* and *Triodia* on red earth").

The adjacent Zanthus population largely inhabits mallee/*Triodia* habitats ( $n = 9$ ; WAM R70891: "open shrub mallee over heath and open/low/dwarf scrub over open spinifex and very low grass on buff gravelly sand"; WAM R72538–39, "*Eucalyptus oleosa* mallee/*Triodia*") and open *Triodia* plains ( $n = 11$ ; WAM R57975: "spinifex and bluebush on a saltlake island"; WAM R59808: "spinifex and sedges"), the latter sometimes with scattered emergents (AM R107954–56: "*Triodia* field with few scattered *Acacia* and *Atriplex* on stony red soil").

The Ooldea population inhabits mixed mallee/*Triodia* associations on a variety of substrates ( $n = 1$ ; SAM R14223: "spinifex-fixed dunes with eucalypt scrub";

SAM R31870: "*Eucalyptus pyriformis*, *Grevillea* open shrubland in rocky gullies and ridges"; SAM R31900–02: "open mallee woodland over *Triodia* on sand dune"; SAM R31948: "open mallee over *Triodia/Melaleuca* on sandy plain with underlying calcrete"; SAM R32067–68: "mallee/*Callitris* open woodland over *Acacia/Eremophila*/spinifex on calcareous interdune"; SAM R32135–36: "low mallee/*Casuarinae/Heterodendron* open woodland over sparse shrubs and *Triodia* on sandy interdune"; SAM R32147: "open mallee over *Acacia/Eremophila*/sparse *Triodia* on sand plain with minor dunes").

Few data are available for the Eyre Peninsula, Flinders Ranges and NSW populations. Specimens have been recorded from mallee/*Triodia* habitats ( $n = 1$ ; AM R105522–31: "mallee woodland with *Triodia* on red sand"; Shea & Wells [1985]: "open mallee woodland [*Eucalyptus socialis*, *Acacia burkittii* and *Dubosia hopwoodii* association] with an understory of *Triodia* cf. *irritans* and *Calotis* sp. on red sandy soil with scattered pieces of calcrete") and a wide range of substrates and topography (SAM R14685: "base of hill"; SAM R14912: "arid low scrub, spinifex, rocky red soil"; SAM R15206: "sandridge"; SAM R19925–27: "rocky hillside").

Most Queensland specimens come from lateritic substrates in "jump-up" country ( $n = 21$ ; AM R110550: "gidyea woodland and spinifex on red gravel"), although one specimen was taken from *Triodia* on "red soil with eucalypt emergents" (WAM R55575).

Centralian specimens have been recorded from both plains (SAM R13229a–b, R29543) and in association with harder substrates and hills (WAM R20847–48: "stony bank of Hugh River"; WAM R31696: "foot of granite tor"; WAM R31697: "foot of stony hill"). One specimen (CAWC R1014) was taken from low tussock grassland (*Enneapogon arenaceus*) under *Acacia aneura* and *A. estropholata*.

In contrast to the *Triodia*-dominated habitats preferred on the mainland, the limited data available suggest different preferences for the Nuyts Archipelago population. Robinson & Smyth (1976) describe it as common in litter and around buildings, while SAM R22483 was taken "under limestone rocks".

**Reproduction.** Male reproductive cycles in *C. m. elongatus* are seasonal (Fig. 29). Enlarged turgid testes  $\geq 5.0$  mm in length were present in most mature-sized males collected between April and September, with some indication of an increase in mean length during this period. In October and November, both enlarged, turgid and small, flattened testes occurred in approximately equal numbers, while between December and March, most testes were small and flattened.

Female reproductive cycles are similarly seasonal (Fig. 30). None of the mature-sized females collected between February and 10 August were gravid. Enlarged yolking ovarian follicles were present between 12 August and 26 October, while unshelled oviducal eggs or developing embryos were present between 25 September and January.

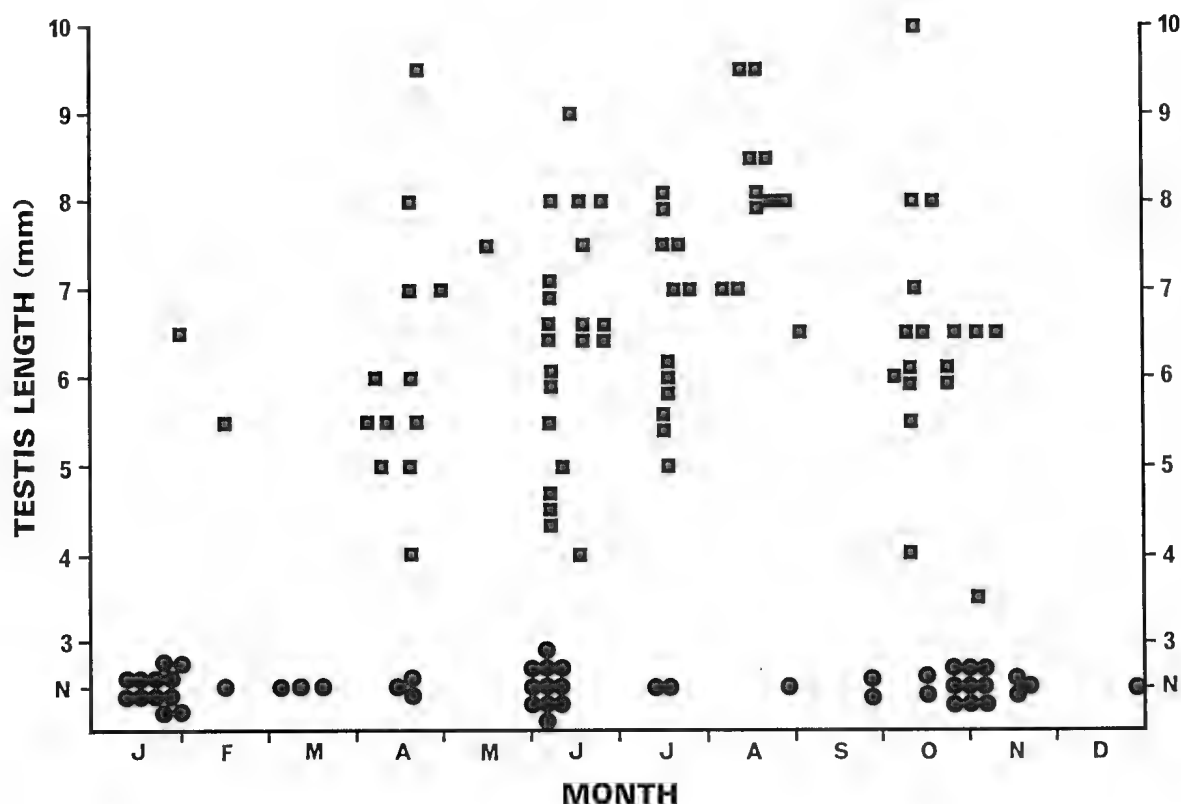


Fig. 29. Seasonal variation in length of turgid testes, and the occurrence of flaccid testes in *Cyclodomorphus melanops elongatus*.

The smallest juveniles (SVL 40.5–42 mm) were collected 27 January.

We conclude from the above data that spermatogenic activity reaches a peak about September, coinciding with mating and fertilisation, and young are born in January.

Of 28 mature-sized females collected between 15 September and 31 November, 13 (46.4%) were gravid, suggesting that reproduction is generally less frequent than annual.

Gravid females carried 2–4 ( $\bar{x}$  = 2.4, mode = 2 (62.5%),  $n$  = 16) enlarged yolking ovarian follicles, unshelled oviducal eggs or fully developed embryos. Litter size was not significantly related to maternal SVL ( $r$  = 0.3055,  $P$  = 0.250).

**Growth rates.** Seasonal distribution of body sizes in the immature material examined (Fig. 31) suggests that mature size is certainly not reached in the first year, and probably not until at least the third year.

**Sex ratio.** The sex ratio of mature-sized material examined was 134 males:148 females, not significantly different to 1:1 ( $\chi^2_1$  = 0.70, n.s.). Seasonal male:female ratios were also not significantly different to equality (summer 17:13,  $\chi^2_1$  = 0.53, autumn 22:32,  $\chi^2_1$  = 1.85, winter 47:64,  $\chi^2_1$  = 2.60, spring 35:32,  $\chi^2_1$  = 0.13), or to each other ( $4 \times 2$  contingency table,  $\chi^2_3$  = 3.59, n.s.).

**Diet and predation.** Stomach contents of specimens we have examined are mainly arthropods, although one specimen (WAM R20980) had eaten a skink, *Proablepharus reginae*.

A second specimen (WAM R41142) is recorded as taken from the gut of a road-killed snake, *Pseudechis australis*.

**Specimens examined.** QUEENSLAND: AM R72028–37, R73325, 92 km west Winton; R110550, R111032, 14 km north-east Scotts Tank, “Diamantina Lakes”; R111033, Scotts Tank, “Diamantina Lakes”; ANWC R1618, R1644, QM J28598–600, “Opalton”; HFWE 0632, within 1 km of Sulieman Creek, 41 km south Dajarra; QM J40188–89, “Diamantina Lakes”; J41828–35, Ooridra area, “Diamantina Lakes”; WAM R55575, 5 km west “Fermoy”. NEW SOUTH WALES (including adjacent SA): AM R16110, Renmark, SA; R105443, R105446, 12.5 km north “Coombah”, NSW; R121029, 166 km north Wentworth, NSW; R130982, 12.4 miles north Coombah Roadhouse via Silver City Hwy, NSW; R130983, 8.4 miles north Coombah Roadhouse via Silver City Hwy, NSW; NTM R5025, Wentworth road, nr Rotten Lake, SA; SAM R15988, R16666a–b, R17125, Danggali Conservation Park, SA. FLINDERS RANGES, SA: SAM R3321, Mt Aroona, 6 miles south-west Copley; R5611, 5 miles west “Arkaroolla”; R10943–44, R10956–57, Paralana Hot Springs; R14912, “Baratta”; R15953a–b, Parachilna; R17457, nr summit Mt Sunderland, Flinders Ranges National Park; R22304–05, Middle Gorge nr Quom. EYRE PENINSULA, SA: AM R105522–31, 31.5 km east-north-east Kimba; MV D10015, “Yardea”; D56659, 28

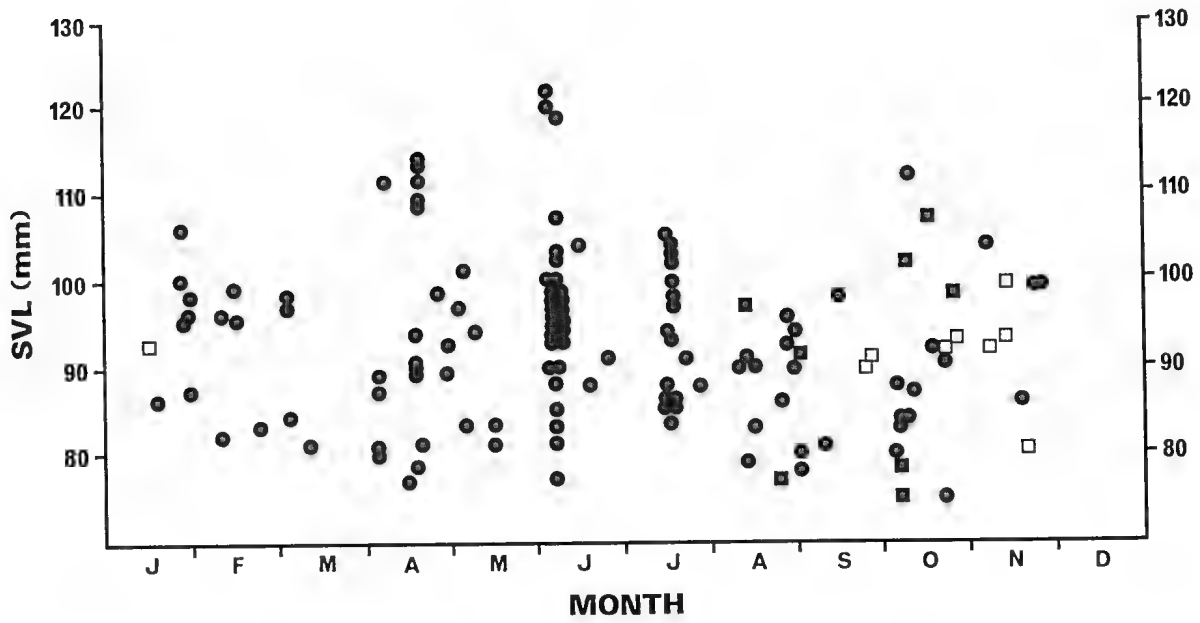


Fig. 30. Seasonal occurrence of non-vitellogenic follicles (dots), yolking ovarian follicles (squares) and oviducal embryos (open squares) in *Cyclodomorphus melanops elongatus*.

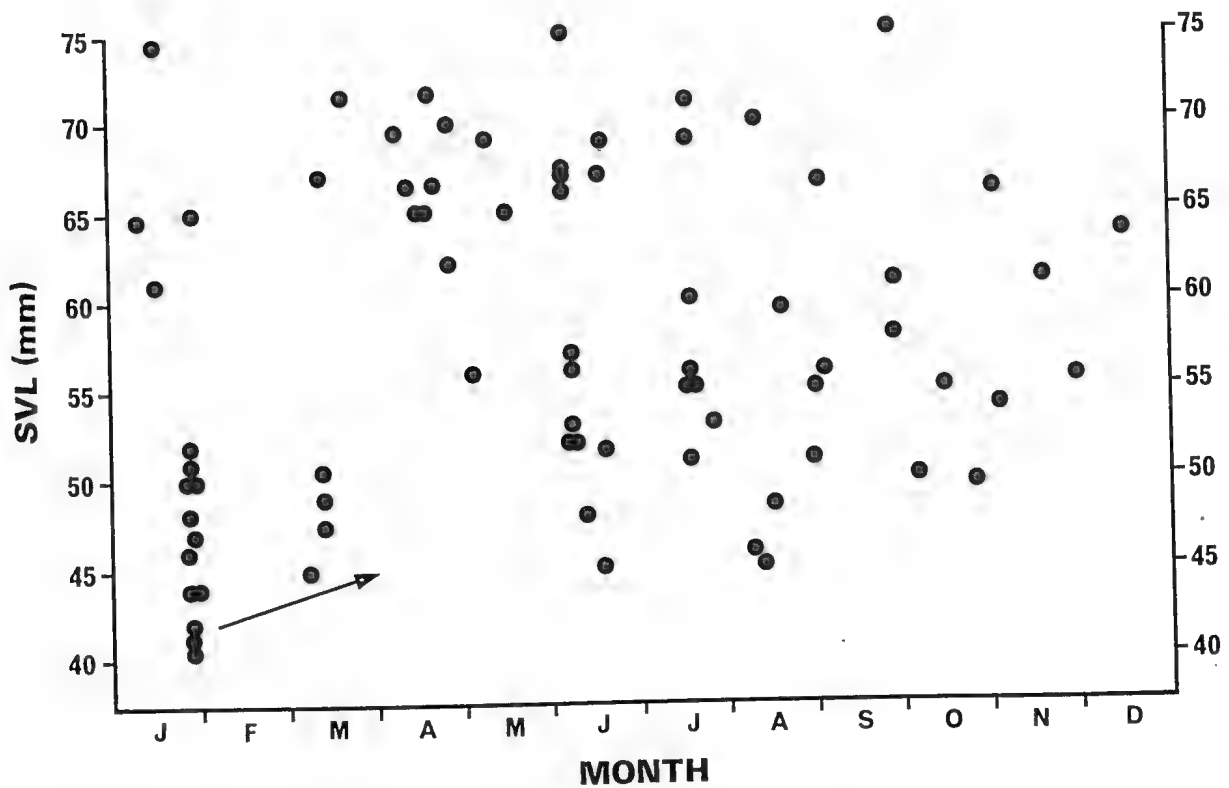


Fig. 31. Seasonal variation in SVL of immature *Cyclodomorphus melanops elongatus*. Arrow indicates inferred growth of first year cohort.



miles west-north-west Iron Knob; NTM R9243, 40 km east Whyalla; SAM R2733, west of Port Augusta; R3058a-c, nr Siam Woolshed, "Cariewerloo"; R3061a-h, Birthday Well, "Cariewerloo"; R3841a-b, Kokatha Hills; R3856a-f, 10 miles south "Yardea"; R3861a-d, "Kondoolka" turnoff, Gawler Ranges; R3870a-b, nr "Kokatha"; R5743, 3 miles east Ucontitchie, 5 miles west Warrambo; R5747a-b, behind Smooth Pool, Streaky Bay; R5767, Elliston; R10729-31, Mamblin; R12460-65, "Corunna"; R12486a-c, R12489a-d, Miccollo Hill, "Siam"; R12618, 5 miles north-west Wharminda; R14202, nr "Minaro Downs"; R14566, Lincoln Hwy, 45 km south-west Whyalla; R14685, R16355a-b, Gum Creek Gorge, Corunna Hills; R14865, "Mt Ive"; R15206, 28 km north-east Wirrulla; R17143, Pinkawillinie Reserve, nr Kimba; R17678, north-west "Yarker" shearing shed; R19925-27, nr Chinaman Dam, "Yardea"; R20613-17, 2 km north-west Corunna Hill North; R27839, Duchess Ridge; R28538-39, 77.5 km north Minnipa; R28541-42, 73 km north Minnipa; R28596, 120 km north-east Minnipa; WAM R24531, 23 miles east-north-east Wirrulla; R25566-67, 10 miles south Kimba. **FLINDERS ISLAND, SA:** SAM R2728a-c, R2729. **NUYTS ARCHipelago, SA:** BMNH 1946.8.17.97-99 (LECTOTYPE and PARALECTOTYPES of *Lygosoma woodjonesii*), SAM R1198, R12879a-b, R21771-77, R22483, St Francis Island; R12864, R21923, Fenellon Island; R21823, Lacy Island. **OOLDEA, SA:** NTM R9202-03, R9287, SAM R17708a-b, R17715, Immarna; SAM R766, R17729, Ooldea; R2731, Barton; R2734a-b, between Ooldea and Talarinna; R14223, Childara Rock Holes; R14444, bomb site, Maralinga; R14957, Mt Finke; R15024a-b, 7 km west Immarna; R18190, 29°15'S 130°15'E; R18240, 29°28'S 130°10'E; R22255, 2 km east Ooldea; R31870, 0.5 km north-east Mt Finke; R31900-02, 14 km west Pinjarra Dam, Yumbarra Conservation Park; R31948, south of Inila Rock Waters, Yumbarra Conservation Park; R32067-68, 5.5 km south Immarna Siding; R32135-36, 9.7 km south-south-west Maralinga; R32147, 8 km south-west Maralinga; WAM R31862, 100 miles north Cook. **ZANTHUS, WA:** AM R107954-56, 45.1 km west by road of Newman Rocks turnoff on Eyre Hwy; WAM R12985-86, R12988, R13547, R16551, R39995, Queen Victoria Spring; R14232-33, Gordons Rocks, 4 miles north Karonie; R16552-53 Goddard Creek, 10 miles east Zanthus; R21654, 4 miles east Chiffley; R21689, 13 miles north-east Cundeelee Mission; R25562, 76 miles east Norseman; R26424-25, Uraryie Rock, Zanthus; R30693-701, 8 miles east Fraser Range; R30716; 13 km east Fraser Range; R30777, 5 miles east Norseman; R30847, Lake Widgiemooltha; R41142, 42 miles east Kalgoorlie; R51064-68, 4 miles north Norseman; R53457-58, Newman Rocks; R57927, 5.5 km north-north-west Clear Streak Well; R57948, 10 km east Boingaring Rocks; R57975, 12 km north-east Charlina Rock; R58050, R59859, R59886, 8 km north Clear Streak Well; R58070, 5 km east Boingaring Rocks; R58071, 4 km east Boingaring Rocks; R59808, 20 km east-south-east Mt Newmont; R59908-09, 12.5 km north-north-east Charlina [sic] Rock; R62284, 31 km east Jindabinbin Rock Hole; R65423, 30.0 km north-west Heartbreak Ridge; R65465, R72387-88, 20 km north-west Heartbreak Ridge; R65504-07, c. 1 km south Buningtonia Spring; R65535, R65630, R72501, R74592, 3.5 km south-west Buningtonia Spring; R65543, 0.5 km south Buningtonia Spring; R70891, 1.0 km north-east Yowie Rock Hole; R72431, Buningtonia Spring; R72440-43, R74563-67, 1.5 km south-west Buningtonia Spring; R72478-79, R72511-12, 1.5 km south-east Buningtonia Spring; R72488-89, 9.0 km north-north-east Buningtonia Spring; R72538-39, 3.0 km south-west Buningtonia Spring; R74543-44, 15 km south-west Buningtonia Spring; R93424, 6 km north-north-east "Southern Hills";

R94040, R94076, 53 km north-north-east Queen Victoria Spring; R94213, 25 km east Newman Rocks. **BOORABBIN, WA:** WAM R19141-42, Red Lake, Coolgardie; R30692, 17 miles west Bulla Bulling; R33968, 16 miles south Karalee; R64751, R64758-60, R64786, Mt Manning Range; R70902, 5.5 km 145° Black Flag; R71174, c. 1 km west Lake Cronin; R71773, 32.5 km south Woolgangie Rail Siding; R71863, R71866, 15 km east Toomey Hills; R72252-53, R72287-89, 31°15'S 120°14'E, Boorabbin area; R72254, R72295-96, 31°13'S 120°13'E, Boorabbin area; R72292, 31°16'S 120°20'E, Boorabbin area; R72720, 6.5 km north-east Comet Vale; R72759, 3.5 km north-east Comet Vale; R73341, R78664-65, 7 km west Mt Manning Range (south-east peak); R78679, 5 km west Mt Manning Range (south-east peak); R78721, 34 km south-south-east Woolgangie; R78723, 21 km south Woolgangie; R78775, Boodarding Rock; R78813, 1 km north-east Boodarding Rock; R83994, 70 km north Bullfinch. **CENTRALIAN:** AM R17177, Mt Gillen, Alice Springs, NT; R17195-244, Erliwunyawunya Rock Hole, Musgrave Ranges, SA; R17339-55, R17361-66, "Mt Davies", Tomkinson Ranges, SA; R106833, "Ti Tree", NT; ANWC R3969, North-West Reserve, SA; CAWC R120, SAM R1569a-f, R2735, Hermannsburg, NT; CAWC R1014, Mereenie, Well No. 6, NT; CAWC R1651, Palm Valley, west end, NT; MV D5071, Central Australia; D51968, Everard Range, SA; SAM R3116a-d, Ernabella Mission, SA; R3721, Bell Rock Range, WA; R11735-36, "Everard Park", SA; R13229a-b, 31 miles south-west Ernabella Mission, SA; R13319, 7 miles east-north-east Ernabella Mission, SA; R29543, 1 km north Victory Well, SA; WAM R20847-48, Owen Springs, NT; R20861, Palm Valley, NT; R20980, 4 miles north-east Blackstone Mining Camp, WA; R31696, 8 miles north-west "Mt Davies" camp, SA; R31697, 5 miles north-west "Mt Davies" camp, SA; R44347, Blackstone Mining Camp, WA; R55362, 146 km north Alice Springs, NT. **OTHERS:** NTM R2986, no locality; SAM R2730, Kangaroo Island, SA [in error].

### *Cyclodomorphus melanops siticulosus* n. subsp.

Figs 32,33

**Type material.** HOLOTYPE: SAM R26399, 15 km west "Nullarbor", in 31°26'S 130°43'E, collected by K. Casperson on 21.ix.1984. PARATYPES: AM R96633-34, 15 km east SA/WA border on Eyre Hwy, SA; R106834, "Arubiddy", WA; R107935, cliff edge 200 m south of Eyre Hwy, 16 km east of WA/SA border, SA; SAM R22979, 17 km east SA/WA border on Eyre Hwy, SA; R26255, 8 km south-east Border Village, SA; WAM R36165, Cave N59, c. 24 miles north-east Madura Pass (GR549083), WA; R36719, 8 miles north Madura, WA.

**Diagnosis.** *Cyclodomorphus m. siticulosus* differs from all other members of the *C. branchialis* species group in the combination of a mode of 24 midbody scales, 56-63 paravertebral scales, 60-62 subcaudal scales,  $\beta$ -temporal configuration, and an olive green to green-brown dorsum without dark spots.

**Description.** Parietals separated by interparietal; interparietal broadest rostrally, approximately  $\frac{3}{4}$  length and breadth of frontal; transversely enlarged nuchals 2-





Fig. 32. Holotype of *Cyclodomorphus melanops siticulosus* (SAM R26399).

5 on each side ( $\bar{x} = 3.1$ ,  $SD = 0.73$ ,  $n = 18$ ), usually three (66.7%); loreals rarely one bilaterally (11.1%,  $n = 9$ ); supraciliaries 5–7 ( $\bar{x} = 6.1$ ,  $SD = 0.42$ ,  $n = 18$ ), usually six (83.3%), first and last largest, third-last usually projecting between second and third supraocular, remainder moderate, subequal; postsuboculars 3–4 ( $\bar{x} = 3.4$ ,  $SD = 0.51$ ,  $n = 18$ ); upper palpebrals 8–9 ( $\bar{x} = 8.2$ ,  $SD = 0.44$ ,  $n = 9$ ); lower palpebrals 8–11 ( $\bar{x} = 9.2$ ,  $SD = 0.97$ ,  $n = 9$ ); secondary temporals in  $\beta$ -configuration; supralabials 7–8 ( $\bar{x} = 7.1$ ,  $SD = 0.32$ ,  $n = 18$ ), third-last below centre of eye, separating pre- and postsuboculars; infralabials 6–7 ( $\bar{x} = 6.3$ ,  $SD = 0.49$ ,  $n = 18$ ), usually first two (88.9%,  $n = 18$ ), rarely first three infralabials contacting postmental; ear moderately large, vertically ovoid, with a single rounded lobule on rostral margin.

Body scales in 22–24 ( $\bar{x} = 23.4$ ,  $SD = 0.88$ ,  $n = 9$ ), usually 24 (66.7%) longitudinal rows at midbody; scales in paravertebral rows much broader than adjacent lateral dorsal scales, 56–63 ( $\bar{x} = 58.8$ ,  $SD = 2.59$ ,  $n = 9$ ); subcaudal scales 60–62 ( $\bar{x} = 61.0$ ,  $SD = 1.00$ ,  $n = 3$ ); lamellae below fourth toe 11–14 ( $\bar{x} = 12.3$ ,  $SD = 1.13$ ,  $n = 18$ ), each with a narrow to broad light to mid-brown callus.

SVL 66–94 mm ( $n = 9$ ); AGL/SVL 52.4–63.3% ( $\bar{x} = 59.0\%$ ,  $n = 9$ ); TL/SVL 97.8–114.6% ( $\bar{x} = 106.8\%$ ,  $n = 3$ ); FLL/SVL 16.5–21.6% ( $\bar{x} = 19.1\%$ ,  $n = 9$ ); HLL/SVL 19.7–26.5% ( $\bar{x} = 24.0\%$ ,  $n = 9$ ); FLL/HLL 72.5–85.0%,  $\bar{x} = 79.8\%$ ,  $n = 9$ ); HL/SVL 16.0–19.1% ( $\bar{x} = 17.8\%$ ,  $n = 9$ ); HW/HL 67.3–75.8% ( $\bar{x} = 72.1\%$ ,  $n = 9$ ); HD/HL 52.3–59.9% ( $\bar{x} = 55.8\%$ ,  $n = 9$ ).

Presacral vertebrae 35–37 ( $\bar{x} = 36.3$ ,  $SD = 0.82$ ,  $n = 6$ ); postsacral vertebrae 35–36 ( $n = 2$ ); phalangeal formula of manus and pes 2.3.4.4.3.

**Allometry:** Although samples are insufficient to determine the direction of allometry for most metric characters,

HLL is significantly negatively allometric in relation to SVL (Table 12).

**Coloration (in preservative)** (Fig. 32). Dorsum mid olive grey-brown; venter pale cream yellow to blue-yellow, more yellow on throat and tail, more blue-yellow on belly. Body scales with slightly darker edges, forming a dark reticulum. Soles cream, with light to mid grey-brown tubercles and calli. Upper lips and sides of neck cream to light grey-brown.

**Coloration (in life).** The iris in AM R96633–34 was orange. In other respects, coloration was not noticeably different to preserved material.

**Details of holotype.** Of the variable characters for the subspecies, the holotype (Figs 32,33) has supraciliaries 5/6, postsuboculars 3/4, nuchals 4/5, supralabials seven, infralabials 6/7, upper palpebrals eight, lower palpebrals nine, midbody scales 22, paravertebral scales 57, subcaudal scales 60, subdigital lamellae 11, presacral and postsacral vertebrae 35, SVL 82 mm, AGL 43 mm, TL 94 mm, FLL 16 mm, HLL 21 mm, HL 15.6 mm, HW 11.0 mm, HD 8.3 mm.

**Sexual dimorphism.** Mature-sized females (SVL 82–94 mm) were larger than mature-sized males (SVL 66–86 mm), although the sample sizes were too small for the differences to be significant (Mann-Whitney U test,  $U = 3$ , n.s.).

There were no significant differences between males and females in mean number of paravertebral scales, midbody scales, subcaudal scales, subdigital lamellae, postsuboculars, supraciliaries, supralabials, infralabials, nuchals, upper palpebrals or lower palpebrals, again at least partly due to the small sample sizes.

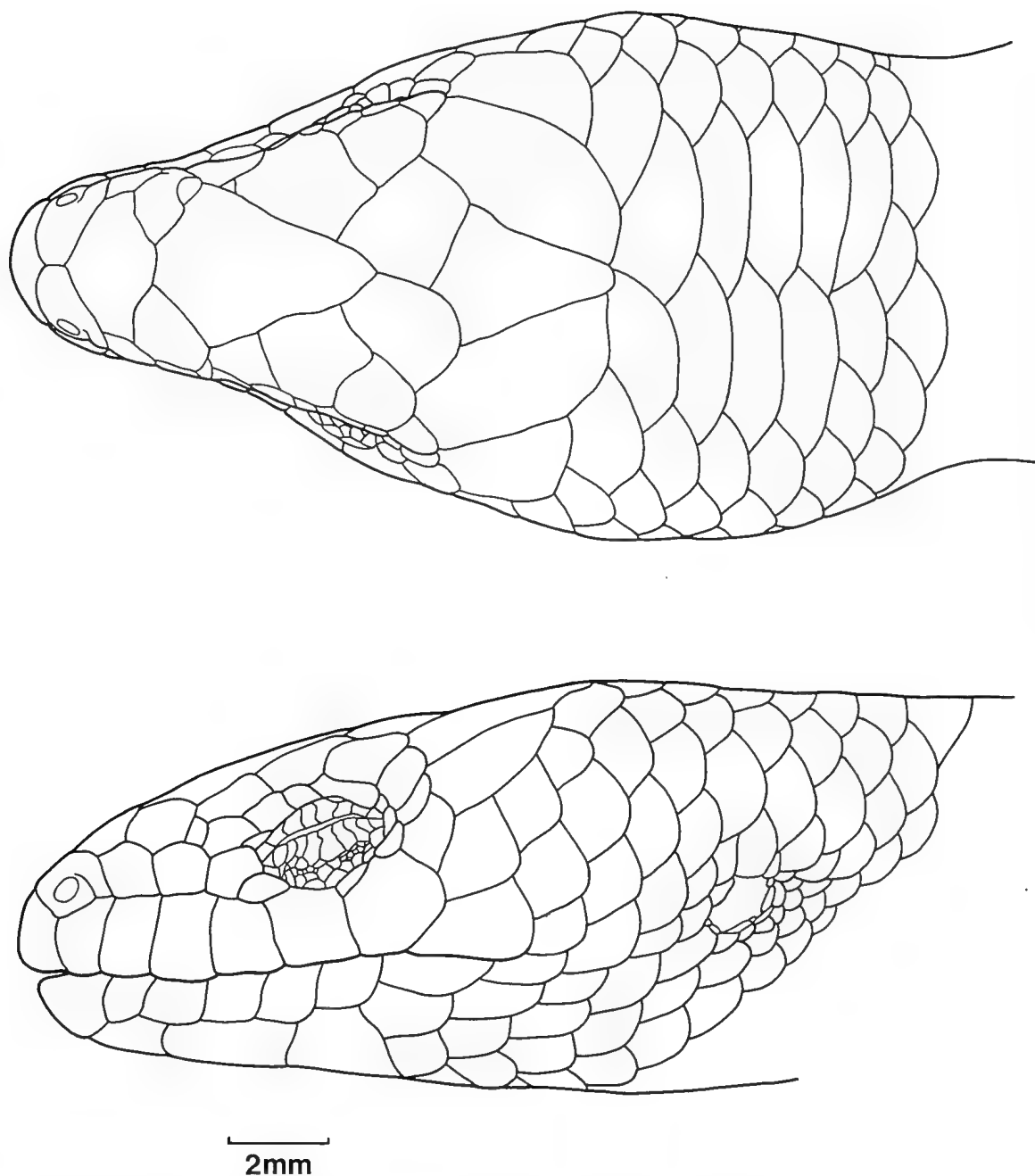


Fig. 33. Head shields of holotype of *Cyclodomorphus melanops siticulosus*.

**Distribution.** *Cyclodomorphus m. siticulosus* is confined to the limestones of the southern fringe and coastal cliffs of the Nullarbor Plain and Hampton Tableland, from "Arubiddy", WA in the west to 15 km west "Nullarbor", SA in the east (Fig. 14).

**Comparison with other taxa.** *Cyclodomorphus m. siticulosus* is very similar to the most geographically proximate race, *C. m. elongatus*, sharing with it the two major diagnostic characters of that race, the uniform olive dorsum and the b-configuration of the lower

secondary temporals, both apomorphic in the context of the *C. branchialis* species group. However, *C. m. siticulosus* is differentiated from *C. m. elongatus* by the very low number of paravertebral scales (56–63,  $\bar{x}$  = 58.8 vs 61–85,  $\bar{x}$  = 72.1), also reflected in a shorter body and consequently longer limbs and head (Table 11, 13) and by a very different habitat and microhabitat preference. The low number of paravertebral scales is an autapomorphy of *C. m. siticulosus*. The three nearest populations of *C. m. elongatus* have lower mean numbers of paravertebral scales than other populations, but even

these are very much higher than in *C. m. siticulosus* (vs Zanthus, 61–77, only 6% with fewer than 64,  $\bar{x}$  = 68.3,  $t_{91}$  = 8.68\*\*\*; vs Ooldea, 64–75,  $\bar{x}$  = 70.0,  $t_{27}$  = 8.30\*\*\*; vs Nuyts, 65–77,  $\bar{x}$  = 71.4,  $t_{27}$  = 10.50\*\*\*). However, the indication of a rapid clinal decrease in paravertebral scales leads us to treat *C. m. siticulosus* and *C. m. elongatus* as only subspecifically distinct.

*Cyclodomorphus m. siticulosus* is an inhabitant of the chenopod plains and low coastal heath on stony kunkar soils of the southern fringe of the Nullarbor Plain and Hampton Tableland, while *C. m. elongatus* is a *Triodia* inhabitant. Known localities for the two races are separated by 225 km in the west ("Arubiddy" vs Goddard Creek and 9 km north-north-east Buningonia Spring) and 150 km in the east (15 km west "Nullarbor" vs Ooldea), although the intervening areas have not been thoroughly surveyed.

*Cyclodomorphus m. siticulosus* differs from *C. m. melanops* in the same characters as *C. m. elongatus*: a uniform olive dorsum,  $\beta$ -configuration of lower secondary temporals, lower number of midbody scales (mode = 24,  $\bar{x}$  = 23.4 vs mode = 26,  $\bar{x}$  = 25.4) and subcaudal scales (60–62,  $\bar{x}$  = 61.0 vs 66–87,  $\bar{x}$  = 74.3), and additionally in the lower number of paravertebral scales, shorter body, and longer limbs and head (Tables 5,12).

*Cyclodomorphus m. siticulosus* differs from both *C. branchialis* and *C. celatus* in coloration (uniform olive green-brown vs greyish with dark streaks, the former also with solid dark "gill" markings on the neck), and further from the latter species in the more open external ear,  $\beta$ -configuration of temporals vs modally  $\alpha$ -pattern, generally lower number of paravertebral scales, and shorter body and consequently longer limbs and head (Tables 1,12).

In addition to marked differences in size, tail length, number of ear lobules and shape of interparietal (as in other races of *C. melanops*), *C. m. siticulosus* differs from *C. maximus* in having a greater number of midbody scales (22–24, mode 24 vs 20–22, mode 22), fewer paravertebral scales (56–63 vs 61–67), presacral vertebrae (36–37 vs 40–42), subdigital lamellae (11–14 vs 14–17), upper palpebrals (8–9 vs 9–12) and lower palpebrals (8–11 vs 10–13),  $\beta$ - vs  $\alpha$ -configuration of secondary temporals and immaculate olive green-brown dorsal ground (vs red-brown to yellow-brown with white spots). It is also shorter-bodied, longer-limbed and longer-headed, and slightly narrower-headed at comparable life-history stages (Tables 4,12).

**Etymology.** The subspecific epithet is derived from the Latin *siticulosus* (very dry, parched) in allusion to the lack of surface water in its habitat.

**Habitat.** Storr (1976) and Storr, Hanlon & Harold (1981), on the basis of the two WAM specimens, considered this race to be cave-inhabiting. However, specific habitat and microhabitat data are lacking for both specimens in the WAM registers, and the only basis

for assuming a cave-inhabiting ecology appears to be the collection of WAM R36165 at Cave N59. This site is notable on the chenopod/limestone plains of the Hampton Tableland for the presence of an isolated stand of mallee in the vicinity (Pilkington & Mott, 1986).

Specific habitat data are available for all of the South Australian specimens. The five specimens from between 8 km south-east Border Village and 17 km east of the SA/WA border all came from low open coastal heath on limestone at or near the top of the coastal cliffline. The most detailed habitat data are for AM R107935 (*Melaleuca* heath with scattered taller *Atriplex* and large expanses of bare limestone pavement with small boulders and exfoliations; soil, where present, thin, grey and of rocky/sandy texture) and SAM R26255, collected at Site ME1 of the joint Nullarbor Survey (McKenzie & Robinson, 1987). The photograph of this latter site (p. 322 in McKenzie & Robinson, 1987) shows low open coastal heath with low eucalypts and melaleucas on a stony plain with crusting loam. The dominant plant species were *Atriplex* spp., *Maireana erioclada*, *Melaleuca puaperiflora*, *M. quadrifaria*, *Rhagodia* spp., *Acacia erinacea*, *A. oswaldii* and mallee eucalypts (*E. brachycalyx*, *E. calcareana*, *E. diversifolia*, *E. gracilis*, *E. oleosa*, *E. rugosa*, *E. socialis*). Four of the five specimens are known to have been taken under limestone rocks and slabs. In the case of AM R107935, the lizard was occupying a short, shallow burrow beneath the rock.

The holotype was collected at Site CA1 of the Nullarbor Survey, "under loose bark, dead tree or log" at a bore (field data sheets stored at South Australian Museum). The photograph of this site (p. 338 in McKenzie & Robinson, 1987) shows low chenopod shrubland on hard clay soils strewn with pebbles, in a shallow depression. The dominant plant species at this site were *Atriplex nummularia*, *Maireana erioclada*, *M. sedifolia*, *Myoporum platycarpum*, *Rhagodia ulicina*, *Selenothamnus squamatus*, *Acacia oswaldii* and *A. papyrocarpa*.

*Triodia* is not recorded from any of the known localities for *C. m. siticulosus*.

**Reproduction.** WAM R36719 (SVL 66 mm; 17.x.1966) is a mature male with 6 mm semiturgid testes. SAM R26399 (SVL 82 mm; 21.ix.1984) has 7 mm turgid testes. Other male specimens ( $n = 5$ ) are mature, but non-reproductive. SAM R22979 (SVL 94 mm; x.1982) is a gravid female with 1L/2R greatly enlarged-yolking ovarian follicles, while AM R106834 (SVL 89 mm; v.1983) has moderately enlarged ovarian follicles. WAM R36165 (SVL 82 mm; 15–28.ii.1970) is a mature but non-reproductive female.

**Sex ratio.** The ratio of mature-sized males:females was 6:3.

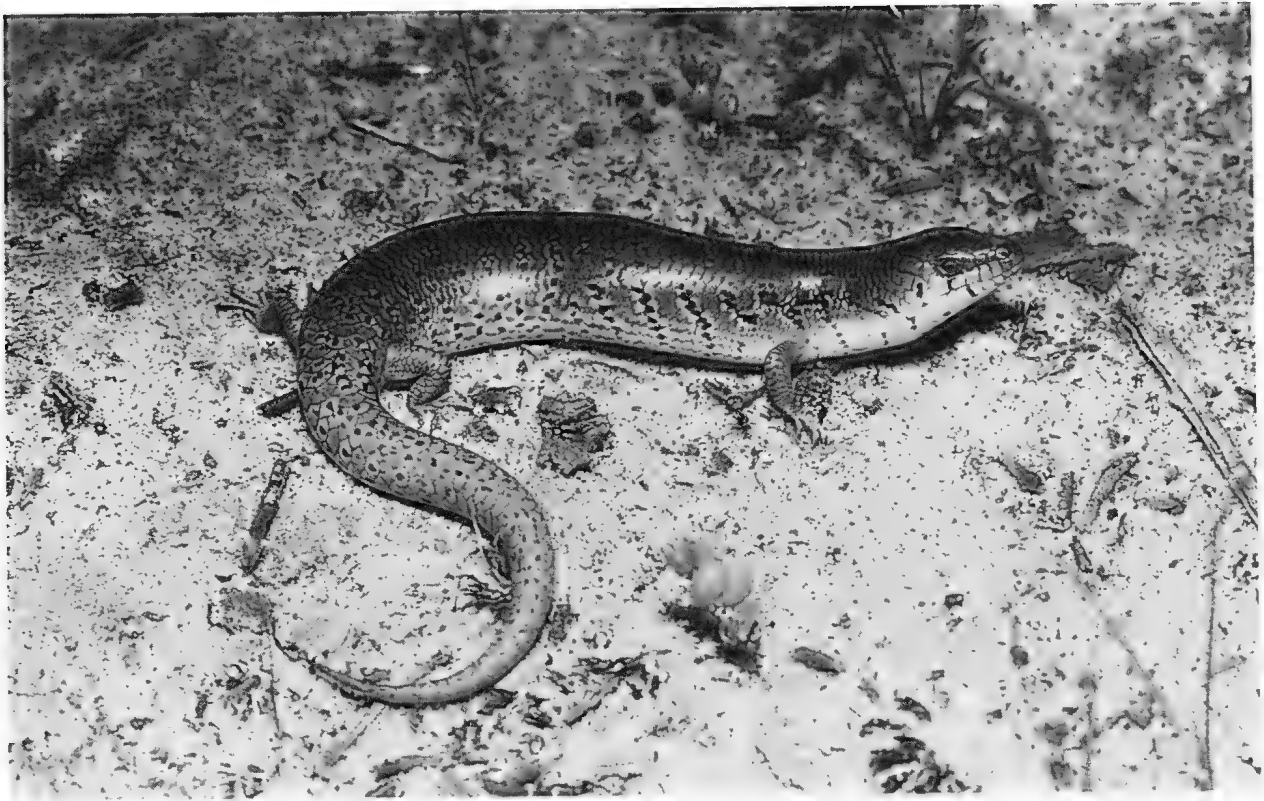


Fig. 34. A live *Cyclodomorphus venustus* from Port Germein, SA.

*Cyclodomorphus venustus* n.sp.

Figs 34–36

**Type material.** HOLOTYPE: SAM R18869, Port Germein, SA, in 33°01'S 138°00'E, collected by T.D. Schwaner on 27.xi.1980. PARATYPES: AM R107969–71, ANWC R2285, R2580, SAM R5370, R5451a–b, R8311, R10200, R11511, R21437, R22969, R24820, R25179–80, R26123–27, R26172–76, Port Pirie, SA; AM R125971, R130977–78, HFW 1624–25, MV D51967, D56351, SAM R17693, R21363, R22980, Port Germein, SA; MV D55887, 4.1 km north-east Manna Hill on Port Augusta–Broken Hill Hwy, SA; SAM R21024, 28 km north “Billa Kalina”, SA; R24415, Wilpena Pound, SA; R24519, Blinman, SA.

**Diagnosis.** *Cyclodomorphus venustus* differs from all other members of the *C. branchialis* species group in the combination of a mode of 24 midbody scales, 51–63 paravertebral scales, 44–54 subcaudal scales, three or more large, black, vertically ovoid patches on the sides of the neck, and a pale grey to red-brown dorsal ground.

**Description.** Parietals completely separated by interparietal (97.5%,  $n = 40$ ) or in narrow contact caudally (2.5%); interparietal broadest rostrally, approximately  $2/3$ – $3/4$  length and breadth of frontal; transversely enlarged nuchals 0–5 on each side ( $\bar{x} = 2.8$ ,  $SD = 0.74$ ,  $n = 80$ ), usually three (72.5%); loreals rarely one unilaterally (5.0%,  $n = 41$ ) or bilaterally (20.0%);

supraoculars rarely one unilaterally (2.5%,  $n = 40$ ); supraciliaries 5–6 ( $\bar{x} = 5.9$ ,  $SD = 0.32$ ,  $n = 80$ ), usually six (88.8%), first and last largest, third last usually projecting between second and third supraocular, remainder moderate, subequal; presuboculars rarely one unilaterally (2.5%,  $n = 40$ ) or bilaterally ( $n = 1$ ); postsuboculars 2–5 ( $\bar{x} = 3.5$ ,  $SD = 0.53$ ,  $n = 80$ ), usually three (50.0%) or four (48.6%); upper palpebrals 6–10 ( $\bar{x} = 7.9$ ,  $SD = 0.84$ ,  $n = 35$ ); lower palpebrals 7–10 ( $\bar{x} = 8.3$ ,  $SD = 0.79$ ,  $n = 36$ ); secondary temporals in  $\alpha$ - (51.4%,  $n = 72$ ) or  $\beta$ - (48.6%) pattern; supralabials usually seven bilaterally (97.5%,  $n = 40$ ), rarely eight unilaterally ( $n = 1$ ); third last below centre of eye, separating pre- and postsuboculars; infralabials 5–7 ( $\bar{x} = 6.1$ ,  $SD = 0.37$ ,  $n = 80$ ), usually six (85.0%), usually first two (96.3%,  $n = 80$ ), rarely first three infralabials contacting postmental; ear small, vertically ovoid, approximately  $2/3$ – $1 \times$  height of eye, usually with one (95.0%,  $n = 80$ ), rarely two (5.0%) rounded to subacute lobules along rostral margin.

Body scales in 21–27 ( $\bar{x} = 24.4$ ,  $SD = 1.21$ ,  $n = 39$ ), usually 24 (46.2%) or more (38.5%) longitudinal rows at midbody; scales in paravertebral rows broader than adjacent lateral dorsal scales, 51–63 ( $\bar{x} = 59.2$ ,  $SD = 2.50$ ,  $n = 40$ ); subcaudal scales 44–54 ( $\bar{x} = 48.3$ ,  $SD = 1.95$ ,  $n = 30$ ); lamellae below fourth toe 10–14 ( $\bar{x} = 11.9$ ,  $SD = 0.93$ ,  $n = 78$ ), each with a narrow light grey-brown callus.

Presacral vertebrae 34–36 ( $\bar{x} = 35.0$ ,  $SD = 0.71$ ,  $n = 9$ ); postsacral vertebrae 27–30 ( $\bar{x} = 28.6$ ,  $SD = 1.13$ ,  $n = 7$ ); phalangeal formula of manus and pes 2.3.4.4.3.

SVL 40–101.5 mm ( $n = 40$ ); AGL/SVL 51.1–64.7% ( $\bar{x} = 58.8\%$ ,  $n = 40$ ); TL/SVL 54.3–95.9% ( $\bar{x} = 72.1\%$ ,  $n = 32$ ), only one longer than 82.4%; FLL/SVL 11.7–25.0% ( $\bar{x} = 18.7\%$ ,  $n = 40$ ); HLL/SVL 18.5–26.9% ( $\bar{x} = 22.3\%$ ,  $n = 40$ ); FLL/HLL 60.0–100.0% ( $\bar{x} = 83.8\%$ ,  $n = 40$ ); HL/SVL 14.8–22.5% ( $\bar{x} = 18.1\%$ ,  $n = 40$ ); HW/HL 60.9–82.4% ( $\bar{x} = 70.1\%$ ,  $n = 40$ ); HD/HL 45.6–66.2% ( $\bar{x} = 52.8\%$ ,  $n = 40$ ).

**Allometry.** In relation to SVL, significant positive allometry was detected for AGL, while negative allometry was present for FLL, HLL and HL (Table 13). Other metric characters did not show statistically significant allometry, although a trend towards positive allometry of TL with respect to SVL was evident.

**Coloration (in preservative)** (Fig. 35). Light to mid grey, grey-brown to pink-brown dorsally and laterally, body and tail with heavy longitudinal black streaks centrally on many dorsal and lateral body scales, most prominent laterally, and aligned in transverse rows (occasionally longitudinally aligned on tail). Black streaks either restricted to base of scales or extend full length of scales, and may be single or paired. Nape dorsally with similar, though smaller and sparser black streaks; laterally with streaks coalescing to form 3–4 vertical black patches between ear and axilla. Head dorsum with only a few fine dark flecks, especially along margins of head shields; laterally with irregular dark margins to some labial scales, particularly the subocular supralabial.

Venter cream to pale yellow-blue, with or without black spots on chin and throat, aligned to form narrow irregular bands, and with or without black spots on body and tail. Pale ventral coloration may extend laterally and dorsally, particularly about transverse rows of black spots. Palms cream with cream to pale brown calli and tubercles.

Juveniles similar to adult, but with darker yellow-brown dorsal ground, and black spots on body and neck dorsum more prominent and tending to coalesce, particularly cranially, to form narrow black bands. Head dorsum slightly darker than body dorsum. Dark markings on body venter very reduced. Laterally, cream spots a little larger and more prominently transversely aligned.

**Coloration (in life)** (Fig. 34). Life colour notes are available for SAM R22969, AM R125971 and AM R130977–78. All had orange irides, blue-black tongues and pink mouth lining. Body coloration and pattern were similar to preserved specimens, except for ground colours (dorsum olive grey-brown becoming pink-red laterally and on tail; venter cream with yellow-orange scale margins forming a reticulum).

**Details of holotype.** Of the variable characters for the species, the holotype (Figs 35,36) has supraciliaries five, postsuboculars three, nuchals 2/3, supralabials seven, infralabials six, upper palpebrals six, lower palpebrals

seven,  $\beta$ -configuration of secondary temporals, rostral ear lobules two, midbody scales 24, paravertebral scales 59, subcaudal scales 47, subdigital lamellae 13/11, presacral vertebrae 35, postsacral vertebrae 27, SVL 92 mm, AGL 55 mm, TL 61 mm, FLL 13 mm, HLL 17 mm, HL 14.6 mm, HW 11.3 mm, HD 8.5 mm.

**Sexual dimorphism.** Mature-sized males were slightly larger than mature-sized females (SVL 79.5–101.5 mm,  $\bar{x} = 89.3$  mm,  $SD = 9.44$ ,  $n = 5$  vs 74–98 mm,  $\bar{x} = 86.1$  mm,  $SD = 7.04$ ,  $n = 18$ ) although the difference was not significant (Mann-Whitney U test,  $U = 38$ , n.s.). Males also had shorter bodies, longer hindlimbs and longer but shallower heads than females (Table 14). Due to the narrow size range for the female sample, the regressions of TL against SVL and FLL against both SVL and HLL were not significant in that sex. These relationships were not tested for sexual dimorphism.

Males had slightly more postsuboculars than females ( $\bar{x}$ 's = 3.8 vs 3.4,  $t_{56} = 2.71^{**}$ ). There were no significant differences between males and females in mean number of paravertebral scales, midbody scales, subcaudal scales, subdigital lamellae, supralabials, infralabials, supraciliaries, nuchals, upper palpebrals or lower palpebrals.

**Distribution.** *Cyclodomorphus venustus* inhabits semi-arid habitats of central and eastern SA, from 28 km north "Billa Kalina" in the west, to 4.1 km north-east Manna Hill in the east, and south to Port Pirie (Fig. 14). Also tentatively associated with this taxon (but not included in the above description) are six specimens and a literature record from the vicinity of the SA/NSW/Qld border: Chunky Creek, nr Tibooburra, NSW (AM R106892), Innamincka, SA (NTM R6986), Betoota Hotel, Qld (QM J28851, J37673), Noccundra Hotel, Qld (AM R133211–12) and Rat Point, NSW (Becker, in Tipping, 1979).

**Geographic variation.** For the purposes of describing geographic variation, the large sample from the two southernmost localities, Port Germein and Port Pirie, was compared to the four specimens from central SA (MV D55887, SAM R21024, R24415, R24519). These two populations are referred to as southern and central. The six atypical specimens from further north are discussed separately, and collectively referred to as the northern sample.

Significant differences occur between southern and central populations in mean number of subcaudal scales (44–51,  $\bar{x} = 48.0$  vs 50–54,  $\bar{x} = 52.0$ ;  $t_{30} = 3.81^{***}$ ), infralabials ( $\bar{x}$ 's = 6.1 vs 6.4,  $t_{78} = 2.03^{*}$ ) and nuchals ( $\bar{x}$ 's = 2.9 vs 2.0,  $t_{78} = 3.56^{***}$ ), but not in number of midbody scales, paravertebral scales, subdigital lamellae, postsuboculars or supraciliaries. The single specimen from Wilpena Pound (SAM R24415), a male, is not only a little larger than other specimens (SVL 101.5 vs up to 98 mm) but is also very much more robust.

The northern sample is similar to *C. venustus* in having solid "gill" markings and a light dorsal ground

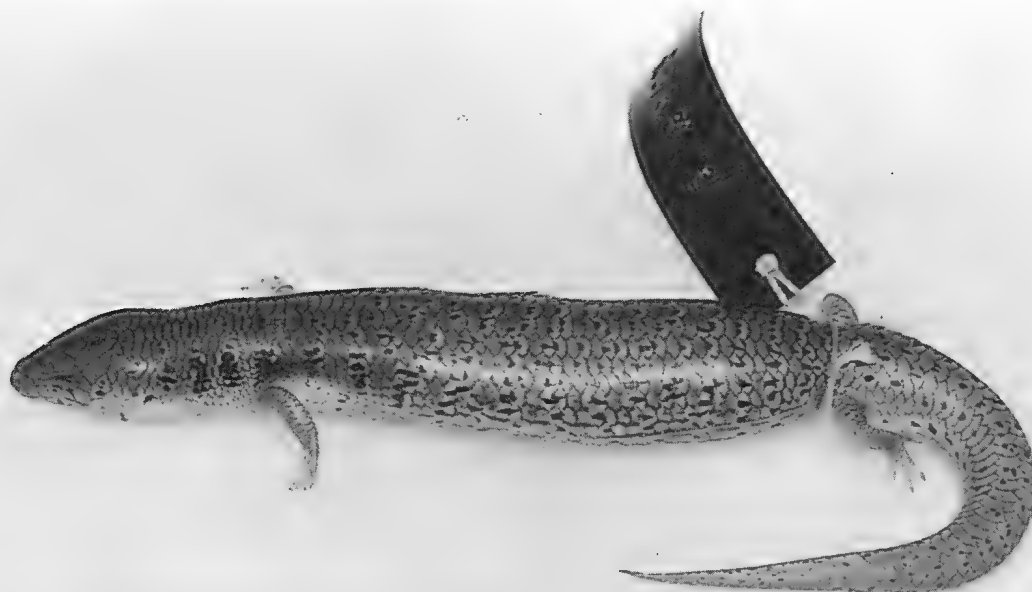


Fig. 35. Holotype of *Cyclodomorphus venustus* (SAM R18869).

(Fig. 37), but has fewer midbody scales (20–24,  $\bar{x}$  = 22.3;  $t_{43}$  = 3.83\*\*\*), postsuboculars (2–3,  $\bar{x}$  = 2.8,  $t_{90}$  = 4.43\*\*\*) and nuchals (0–3,  $\bar{x}$  = 2.0,  $t_{90}$  = 3.23\*\*\*), more paravertebral scales (58–64,  $\bar{x}$  = 62.0,  $t_{44}$  = 2.58\*), presacral vertebrae (37–40,  $\bar{x}$  = 38.8,  $t_{11}$  = 6.30\*\*\*) and subcaudal scales (69–74 in the two specimens with complete tails), a consistent  $\alpha$ -configuration of secondary temporals, a longer tail (101.1–108.1% of SVL), and dorsal and lateral pattern very reduced (absent or almost so dorsally, reduced to sparse black spots, basal on scales laterally on body and tail, and lateral nuchal markings reduced to black or grey smudges; dorsal ground light sandy yellow-brown or grey-brown). Our assignment of this sample to *C. venustus*, despite its very different scalation in several characters, is largely on the basis of the synapomorphy of presence of dark “gill” markings, geographic proximity, and the suggestion of a clinal increase in subcaudal scales and a decrease in nuchal scales from south to north. Further collections, especially from intervening areas, may result in the recognition of this population as a distinct taxon.

**Comparison with other taxa.** *Cyclodomorphus venustus* (*sensu stricto*) differs from all other taxa in the *C. branchialis* species group in having only 44–54 subcaudal scales (minimum for other species 57, in *C. branchialis*), an autapomorphy in the context of the *C. branchialis* species group. This difference is also reflected in a shorter tail (Tables 1–6) and lower number of postsacral vertebrae (27–30 vs minimum of 32, in *C. branchialis*). In other respects, particularly in coloration, *C. venustus* is most similar to *C. branchialis*, although geographically separated from it by over 1870 km, with *C. m. elongatus* occupying much of the gap. Despite the almost identical colour pattern to *C. branchialis*, southern and central populations of *C. venustus* have fewer paravertebral (51–

63 vs 62–70) and subcaudal (44–54 vs 57–64) scales, but more numerous postsuboculars ( $\bar{x}$  = 3.5 vs 2.6,  $t_{112}$  = 8.30\*\*\*, modes three vs two) and subdigital lamellae ( $\bar{x}$  = 11.9 vs 10.8,  $t_{108}$  = 6.02\*\*\*), as well as a greater variation in the temporal configuration (49% vs 86% in  $\beta$ -pattern). Some of these differences (paravertebrals, subcaudals) are not maintained in the northern population of *C. venustus*, although the differences in mean number of postsuboculars ( $\bar{x}$  = 2.8, mode 3 [83.3%],  $n$  = 12) and subdigital lamellae (10–14,  $\bar{x}$  = 11.9,  $n$  = 12) remain, while the difference in the temporal configuration is enhanced (all six of the northern *venustus* have the  $\alpha$ -pattern). Further, in the northern *venustus* the number of subcaudals (69–74,  $n$  = 2) is greater than in *C. branchialis*, while the coloration is paler, with the “gill” markings on the neck less developed, and the strong lateral and dorsal pattern present on most *C. branchialis* almost absent.

The presence of dark “gill” markings on the neck would seem to be a synapomorphy linking *C. branchialis* and *C. venustus*, and it is possible that they should be treated as subspecies of a single species. However, we believe that the extreme geographic separation of the two taxa, together with evidence of morphological differentiation in scalation and body proportions, constitutes a case for the two taxa being on distinct “phylogenetic trajectories” (Frost & Hillis, 1990: 90) and having “distinct evolutionary tendencies and historical fate” (Wiley, 1978: 18), and hence warranting distinct specific status using the evolutionary species concept.

*Cyclodomorphus venustus* differs from *C. celatus* in its smaller adult size (mature SVL 74–101.5 mm vs 82–121 mm), shorter body (AGL/SVL: Tables 2,13), longer limbs (Tables 2,13), greater number of midbody scales (mostly 24 or more, vs usually 22 or fewer), lower number of paravertebral scales (51–63 vs 61–77), and



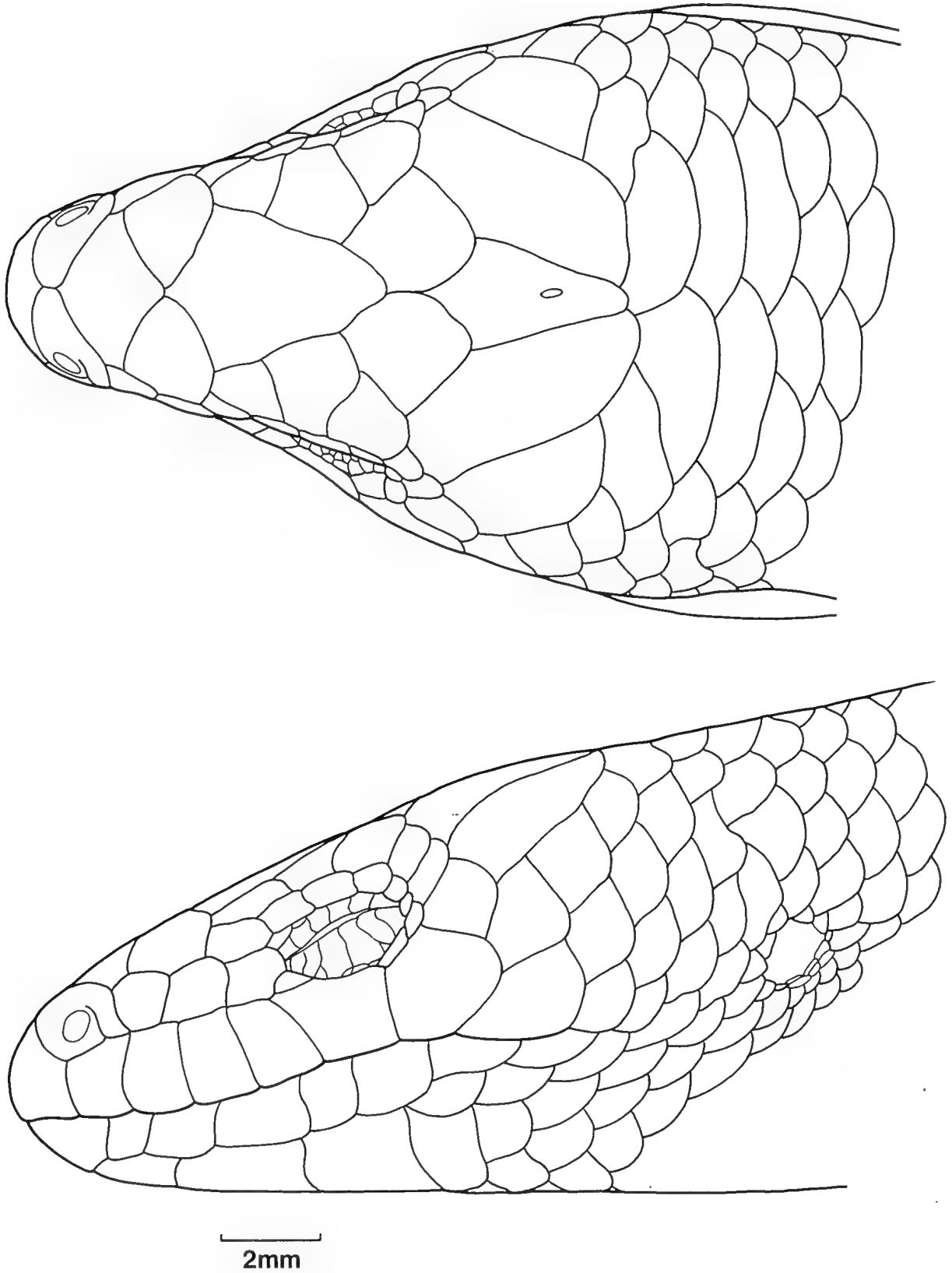


Fig. 36. Head shields of holotype of *Cyclodomorphus venustus*.





Fig. 37. A live individual of the northern form of *Cyclodomorphus venustus* from Noccundra Hotel, Qld.

in colour pattern, with fusion of the lateral nuchal markings to form solid black bars and reduction of the black streaks to basal spots. The reddish flush seen in many southern and central *C. venustus* has not been observed in *C. celatus*.

In addition to the marked differences in body size, tail length, number of ear lobules and shape of interparietal, *C. venustus* differs from *C. maximus* in its greater number of midbody scales (usually 24 or more vs mode 22), fewer paravertebral scales (51–63 vs 61–67), presacral vertebrae (34–36 vs 40–42), subdigital lamellae (10–14 vs 14–17), upper palpebrals (6–10 vs 9–12) and lower palpebrals (7–10 vs 10–13), shorter body (and therefore longer limbs and head) and narrower head (Tables 4,13), and in coloration (solid “gill” markings, strong dark spotting and streaking on body and tail vs no dark markings on body and tail, but pale spots and a dark circumocular ring present).

*Cyclodomorphus venustus* further differs from *C. m. melanops* in its very much smaller size (SVL to 101.5 mm vs 132 mm), shorter body (Tables 5,13), with fewer paravertebral scales (51–63 vs 62–80) and presacral vertebrae (34–36 vs 38–42), lower mean number of subdigital lamellae (10–14,  $\bar{x}$  = 11.9 vs 10–18,  $\bar{x}$  = 14.1), slightly lower mean numbers of upper palpebrals (6–10,  $\bar{x}$  = 7.9 vs 7–13,  $\bar{x}$  = 9.7) and lower palpebrals (7–10,  $\bar{x}$  = 8.3 vs 7–14,  $\bar{x}$  = 10.9), and possession of solid dark “gill” markings.

*Cyclodomorphus venustus* is geographically closest to *C. m. elongatus*. Within the Flinders Ranges, the two

taxa approach to within approximately 15 km between Wilpena Pound and Mt Sunderland and 27 km between Blinman and Parachilna. In addition to the shorter tail, *C. venustus* differs from *C. m. elongatus* in its smaller size (SVL to 101.5 mm vs 125 mm), shorter body (Tables 10,13), with fewer paravertebral scales (51–63 vs 61–85) and presacral vertebrae (34–36 vs 38–44), and strong colour pattern (absent or almost so in *C. m. elongatus*). Within the Flinders Ranges, *C. m. elongatus* has an even greater number of paravertebral scales (73–84,  $\bar{x}$  = 77.7), suggesting character displacement.

*Cyclodomorphus venustus* and *C. m. siticulosus* are similar in size and body length, and in habitat preferences (chenopods and coastal heaths, often on stony soils). In addition to the difference in tail length, however, the two taxa differ in the complete lack in *C. m. siticulosus* of the strong colour pattern of *C. venustus*, and the variable temporal pattern of *C. venustus* (consistently  $\beta$ -in *C. m. siticulosus*). Geographically, the two taxa are separated by *C. m. elongatus* on Eyre Peninsula and in the Gawler Ranges.

**Etymology.** The specific epithet is from the Latin *venustus* (lovely, beautiful) in allusion to the bright coloration of this species.

**Habits and habitats.** The Port Pirie and Port Germein populations inhabit coastal samphire flats (SAM R26172–76) and low heath (pers. obs.). Most specimens have

been taken from under rubbish in dumps and tips. Ehmann (1992) reports the species (as *Cyclodomorphus* sp.) from "low-lying saline flats and old stranded foredunes above the influence of most high tides but subject to low, slow sheet flooding during extreme tides... or especially after very heavy rain. Soils are saline clays, often containing grit, especially on the coast. Also inland samphire plains... ". He also reports burrow construction in this species: "the Samphire Omolepida digs a home burrow which starts under a samphire bush and extends up to 1.5 metres more or less horizontally through the saline loamy... soil. The burrow has risers as well as air traps to retard entry of water due to flooding or high tides. It can remain submerged for up to an hour and is not distressed by being completely covered by water in a confined space. While foraging away from the home burrow, it shelters under more superficial cover such as matted and procumbent vegetation". Individuals we have held in captivity have readily burrowed into loose sand, gravel and leaf litter, and spent much of the time below the surface.

Specific habitat data are available for all four specimens in the central sample. SAM R21024 was taken in a pitfall trap in gibber plains with cracking clay and low dense chenopods. MV D55887 was found under railway sleepers in an open saltbush-bluebush plain. SAM R24519 was found under tin on sandy soil by a ruined building, while SAM R24415 was taken under *Triodia* on a scree slope.

Of the northern material, QM J28851 was found under a small sheet of iron on a bare gibber plain (J. Covacevich, pers. comm.), and the Noccundra Hotel specimens were found under tin in a rubbish tip (L. Voigt, pers. comm.) while the habitat at Chunky Creek (AM R106892) has been described by Denny (1975): close to the creek, the dominant plants are "a mixture of sedge, *Leptochloa digitata* and a small bush (*Chenopodium* species) with a scattering of Coolabah trees (*Eucalyptus microtheca*) and an undergrowth of native clover (*Medicago* sp.)" on "red cracking soil"; successively more distant from the creek are "a vegetation complex of *Bassia quinquecupis* as the dominant species" and "a stand of grass containing such species as Mitchell, Flinders, Umbrella (*Chloris acicularis*) and Ray (*Sporobolus actinocladius*)."

**Reproduction.** Ehmann (1983) recorded a litter of two for this species, born 9.ii.1982. The young at birth were 41 and 42 mm SVL, with mass 1.28 and 1.19 g respectively. This record is based on HFWE 1624–25, born to a Port Germein specimen (H. Ehmann, pers. comm.). Ehmann (1992) subsequently reported a litter of three born in early February, possibly also based on the above record, and in error.

Males collected in September and October ( $n = 4$ ) had enlarged, semiturgid to turgid testes 7–10 mm long.

Three gravid females (SVL 90.5–92 mm) were collected between 27 October and 27 November, and carried 2–4 ( $n = 2$ ) unshelled oviducal eggs. Other

mature-sized females ( $n = 15$ ) collected between 16 January and 29 October were non-gravid, although some of those collected in September and October had slightly enlarged ovarian follicles.

**Sex ratio.** The ratio of mature-sized males:females is 5:18, a ratio significantly different from equality ( $\chi^2_1 = 6.26^*$ ).

**Diet.** The diet of this species has been reported to include "spiders, cockroaches, centipedes, snails, and smaller skinks", captured by "stealth and ambush" (Ehmann, 1992).

**Conservation status.** Cogger *et al.* (1993) identify this species (as *Cyclodomorphus* sp. [Samphire, SA]) as RARE or INSUFFICIENTLY KNOWN in a national comparison of reptiles of conservation significance.

A Key to the Genus *Cyclodomorphus*

1. Postnarial groove absent; paravertebral scales not or only slightly broader than adjoining lateral dorsal scales.....2
- Postnarial groove present; paravertebral scales noticeably broader than adjoining lateral dorsal scales ..... 3
2. Postmental contacting a single infralabial on each side; 26–34 midbody scales; 14–17 subdigital lamellae; east coast NSW and Queensland..... *C. gerrardii*
- Postmental contacting two infralabials on each side; 20–26 midbody scales; 8–14 subdigital lamellae; Tasmania and coast and ranges of eastern Victoria and NSW ..... *C. casuarinae* complex \*
3. SVL up to 231 mm; interparietal much smaller than frontal ( $\frac{1}{2}$ – $\frac{2}{3}$  length,  $\frac{1}{3}$ – $\frac{1}{2}$  breadth in adults, slightly larger in juveniles); north-west Kimberley ..... *C. maximus*
- SVL up to 132 mm; interparietal only a little smaller than frontal ( $\frac{3}{4}$ – $\frac{9}{10}$  length;  $\frac{2}{3}$ – $\frac{9}{10}$  breadth in adults, slightly larger in juveniles)..... 4
4. Three large solid black to grey, vertically ovoid patches on side of neck between ear and axilla; subcaudal scales 44–64 ..... 5
- Side of neck without solid dark ovoid markings; subcaudal scales 58–87 ..... 6
5. Subcaudal scales 44–54; paravertebral scales 51–63; South Australia ..... *C. venustus*
- Subcaudal scales 57–64; paravertebral scales 62–70; Geraldton region, WA ..... *C. branchialis*
6. Midbody scales usually 20–22; ear narrow, slit-like, usually without obvious lobules; sides of neck with 3–4 vertical series of short black streaks; west coast of WA, south of “Gnaraloo” ..... *C. celatus*
- Midbody scales usually 24–29; ear open, usually with a single lobule on rostral margin; sides of neck immaculate or with scattered black spots (not streaks)..... 7
7. Secondary temporals usually in  $\alpha$ -configuration; venter usually with black spots; dorsum with or without black spots; southern Kimberley, Pilbara, central Australia ..... *C. m. melanops*
- Secondary temporals usually in  $\beta$ -configuration; body and tail immaculate, rarely with a few dark flecks ventrally ..... 8
8. Paravertebral scales 61–85; *Triodia* habitats; WA Goldfields east to western NSW, western Qld, central Australia ..... *C. m. elongatus*
- Paravertebral scales 56–63; chenopod habitats; Nullarbor Plains and Hampton Tableland ..... *C. m. siticulosus*

\* See Shea (1995) for a key to the three species in this complex.

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**Table 1.** Allometric equations and calculated values for cranial and somatic proportions in *Cyclodomorphus branchialis*. Values a and b solve the equation  $y = bx^a$ , r = correlation coefficient, s.e. = standard error of a,  $C_{51}$ ,  $C_{88}$  are calculated percentage proportions (y/x) at SVL = 51 and 88 mm (minimum and maximum size of the material seen, although the minimum almost certainly does not represent neonate size). Sample sizes are as for ratios.

y	x	a	b	r	s.e.	$C_{51}$	$C_{88}$
AGL	SVL	1.1664	0.289	0.9893	0.0445	55.6	60.9
TL	SVL	1.2395	0.296	0.9468	0.1490	75.9	86.5
FLL	SVL	0.7497	0.496	0.9173	0.0903	18.5	16.2
HLL	SVL	0.8430	0.419	0.9141	0.1000	22.6	20.7
FLL	HLL	1.0440	0.700	0.9605	0.0839	78.0	79.5
HL	SVL	0.7749	0.484	0.9452	0.0716	20.0	17.7
HW	HL	1.1627	0.476	0.9334	0.1195	69.4	74.4
HD	HL	1.1458	0.375	0.9065	0.1426	52.6	55.9

**Table 2.** Allometric equations and calculated values for cranial and somatic proportions in *Cyclodomorphus celatus*. Values a and b solve the equation  $y = bx^a$ , r = correlation coefficient, s.e. = standard error of a,  $C_{38}$ ,  $C_{83}$ ,  $C_{121}$  are calculated percentage proportions (y/x) at SVL = 38, 83 and 121 mm (minimum, minimum mature and maximum size). Sample sizes are as for ratios.

y	x	a	b	r	s.e.	$C_{38}$	$C_{83}$	$C_{121}$
AGL	SVL	1.1229	0.373	0.9916	0.0101	58.3	64.2	67.2
TL	SVL	1.2784	0.270	0.9765	0.0306	74.3	92.4	102.6
FLL	SVL	0.6770	0.616	0.8960	0.0233	19.0	14.8	13.1
HLL	SVL	0.7615	0.566	0.9022	0.0254	23.8	19.7	18.0
FLL	HLL	0.8656	1.092	0.9646	0.0165	81.2	75.0	72.2
HL	SVL	0.6377	0.788	0.9575	0.0133	21.1	15.9	13.9
HW	HL	0.9755	0.727	0.9546	0.0211	69.1	68.2	67.8
HD	HL	1.0919	0.438	0.9434	0.0266	53.0	55.5	56.8

**Table 3.** Sexual dimorphism in cranial and somatic proportions in *Cyclodomorphus celatus*. Tests of significance (i) and allometric and calculated values for males (ii) and females (iii) in sexually dimorphic characters. Conventions for (ii) and (iii) as for Table 1, except for n (sample size).  $C_{83}$  and  $C_{115}$  are calculated proportions at SVL = 83, 115 mm (mean minimum size at maturity, and maximum size for males, the smaller sex).

(i)

y	x	Slopes			Intercepts		
		F	d.f.	P	F	d.f.	P
AGL	SVL	0.004	1,112	n.s.	58.904	1,113	***
TL	SVL	0.003	1,28	n.s.	18.044	1,29	***
FLL	SVL	4.861	1,111	*	70.774	1,112	***
HLL	SVL	11.335	1,109	***	—	—	—
FLL	HLL	0.213	1,109	n.s.	0.501	1,110	n.s.
HL	SVL	4.701	1,112	*	134.486	1,113	***
HW	HL	0.722	1,112	n.s.	1.051	1,113	n.s.
HD	HL	0.195	1,112	n.s.	2.603	1,113	n.s.

(ii)

y	x	a	b	r	s.e.	n	$C_{83}$	$C_{115}$
AGL	SVL	1.115	0.378	0.971	0.035	65	62.8	65.2
TL	SVL	1.144	0.511	0.949	0.101	16	96.6	101.2
FLL	SVL	0.637	0.775	0.781	0.065	64	15.6	13.8
HLL	SVL	0.844	0.410	0.846	0.068	63	20.6	19.6
HL	SVL	0.750	0.490	0.929	0.038	65	16.2	15.0

(iii)

AGL	SVL	1.118	0.389	0.984	0.029	51	65.5	68.1
TL	SVL	1.134	0.486	0.882	0.162	16	87.9	91.8
FLL	SVL	0.412	1.956	0.590	0.081	51	14.6	12.0
HLL	SVL	0.476	1.933	0.619	0.087	50	19.1	16.1
HL	SVL	0.631	0.782	0.918	0.039	51	15.3	13.6

**Table 4.** Allometric equations and calculated values for cranial and somatic proportions in *Cyclodomorphus maximus*. Values a and b solve the equation  $y = bx^a$ , r = correlation coefficient, s.e. = standard error of a,  $C_{62}$ ,  $C_{157}$ ,  $C_{231}$  are calculated percentage proportions (y/x) at SVL = 62, 157 and 231 mm (minimum, mean minimum mature and maximum size). Correlation between tail length and SVL not calculated due to limited data. Sample sizes are as for ratios.

y	x	a	b	r	s.e.	$C_{62}$	$C_{157}$	$C_{231}$
AGL	SVL	1.1201	0.344	0.9997	0.0071	56.5	63.1	66.1
FLL	SVL	0.6665	0.837	0.9952	0.0160	21.1	15.5	13.6
HLL	SVL	0.7897	0.599	0.9977	0.0130	25.1	20.7	19.1
FLL	HLL	0.8435	1.293	0.9968	0.0163	84.1	75.0	71.5
HL	SVL	0.6456	0.919	0.9954	0.0151	21.3	15.3	13.4
HW	HL	1.0700	0.585	0.9938	0.0289	70.1	73.1	74.4
HD	HL	1.1015	0.383	0.9926	0.0327	49.8	52.9	54.2

**Table 5.** Allometric equations and calculated values for cranial and somatic proportions in *Cyclodomorphus melanops melanops*. Values a and b solve the equation  $y = bx^a$ , r = correlation coefficient, s.e. = standard error of a,  $C_{41}$ ,  $C_{83}$ , and  $C_{132}$  are calculated percentage proportions (y/x) at SVL = 41, 83, and 132 mm (minimum, minimum mature, and maximum size). Sample sizes are as for ratios.

y	x	a	b	r	s.e.	$C_{41}$	$C_{83}$	$C_{132}$
AGL	SVL	1.1419	0.335	0.9888	0.0084	56.7	62.7	67.0
TL	SVL	1.2476	0.351	0.9516	0.0351	88.0	104.8	117.6
FLL	SVL	0.6186	0.904	0.8699	0.0173	21.9	16.8	14.0
HLL	SVL	0.6832	0.886	0.8869	0.0175	27.3	21.9	18.9
FLL	HLL	0.8667	1.129	0.9394	0.0156	81.8	76.7	73.5
HL	SVL	0.6507	0.737	0.9071	0.0147	20.1	15.7	13.4
HW	HL	1.0708	0.611	0.9541	0.0162	71.0	73.3	74.9
HD	HL	1.1232	0.410	0.9372	0.0202	53.2	56.3	58.4



**Table 6.** Sexual dimorphism in cranial and somatic proportions in *Cyclodomorphus melanops melanops*. Tests of significance (i) and allometric and calculated values for males (ii) and females (iii) in sexually dimorphic characters. Conventions for (ii) and (iii) as for Table 3.  $C_{83}$  and  $C_{126}$  are calculated proportions at SVL = 83, 126 mm (mean minimum size at maturity, and maximum size for males, the smaller sex).

(i)		Slopes			Intercepts		
y	x	F	d.f.	P	F	d.f.	P
AGL	SVL	2.621	1,235	n.s.	43.591	1,236	***
TL	SVL	0.069	1,63	n.s.	3.901	1,64	n.s.
FLL	SVL	4.349	1,230	*	36.560	1,231	***
HLL	SVL	6.669	1,230	**	—	—	—
FLL	HLL	0.072	1,231	n.s.	0.168	1,232	n.s.
HL	SVL	6.346	1,235	*	54.197	1,236	***
HW	HL	0.096	1,238	n.s.	8.933	1,239	**
HD	HL	0.674	1,238	n.s.	3.420	1,239	n.s.

(ii)		a	b	r	s.e.	n	$C_{83}$	$C_{126}$
AGL	SVL	1.034	0.536	0.960	0.030	101	62.3	63.2
FLL	SVL	0.663	0.765	0.770	0.056	99	17.3	15.0
HLL	SVL	0.674	0.959	0.760	0.058	100	22.7	19.8
HL	SVL	0.868	0.286	0.860	0.052	100	16.0	15.1
HW	HL	0.936	0.869	0.912	0.042	101	73.7	72.0

(iii)		a	b	r	s.e.	n	$C_{83}$	$C_{126}$
AGL	SVL	1.098	0.412	0.963	0.026	138	63.5	66.2
FLL	SVL	0.491	1.581	0.579	0.060	135	16.7	13.5
HLL	SVL	0.464	2.328	0.580	0.057	134	21.8	17.4
HL	SVL	0.685	0.618	0.758	0.050	139	15.4	13.5
HW	HL	0.953	0.845	0.909	0.037	141	75.0	74.0

**Table 7.** Geographic variation in mean number of paravertebral scales in *Cyclodomorphus melanops melanops*. Pairwise comparisons between the ten highest means (horizontal) and the five lowest means (vertical). Means are in parentheses. Significant differences at the 5% level are indicated by asterisks. All other pairs of means not significantly different. Populations identified by the first letter(s) of their names.

	M	N	H	T	Oa	On	LA	GS	C	UA
	(73.0)	(72.8)	(72.2)	(72.2)	(67.7)	(71.9)	(71.7)	(70.6)	(70.0)	(69.3)
C (70.0)	*	—	—	—	*	—	—	—	—	—
UA (69.3)	*	—	*	—	*	*	—	—	—	—
K (68.0)	*	*	*	*	*	*	*	—	*	—
E (67.7)	*	*	*	*	*	*	*	—	*	—
BI (66.6)	*	*	*	*	*	*	*	*	*	*

**Table 8.** Geographic variation in mean number of subdigital lamellae in *Cyclodomorphus melanops melanops*. Pairwise comparisons between the seven highest means (horizontal) and all other means. Conventions as for Table 7.

	E	K	BI	M	H	On	Oa
	(15.2)	(14.6)	(14.5)	(14.4)	(13.9)	(13.9)	(13.7)
K (14.6)	*	—	—	—	—	—	—
BI (14.5)	*	—	—	—	—	—	—
M (14.4)	*	—	—	—	—	—	—
H (13.9)	*	*	*	—	—	—	—
On (13.9)	*	*	*	—	—	—	—
Oa (13.7)	*	*	*	*	—	—	—
N (13.7)	*	*	—	—	—	—	—
T (13.7)	*	—	—	—	—	—	—
UA (13.2)	*	*	*	*	—	—	—
LA (13.2)	*	*	*	*	—	—	—
GS (12.8)	*	*	*	*	—	—	—
C (12.6)	*	*	*	*	*	*	*

**Table 9.** Geographic variation in mean number of supralabial scales in *Cyclodomorphus melanops melanops*. Pairwise comparisons between the ten highest means (horizontal) and the seven lowest means (vertical). Conventions as for Table 7.

		LA (7.9)	E (7.7)	M (7.6)	N (7.6)	H (7.5)	On (7.5)	Oa (7.5)	T (7.4)	UA (7.3)	BI (7.3)
Oa	(7.5)	*	—	—	—	—	—	—	—	—	—
T	(7.4)	—	—	—	—	—	—	—	—	—	—
UA	(7.3)	*	*	—	—	—	—	—	—	—	—
BI	(7.3)	*	*	*	—	*	—	—	—	—	—
GS	(7.1)	*	*	*	—	*	—	*	—	—	—
C	(7.0)	*	*	*	*	*	*	*	—	*	*
K	(7.0)	*	*	*	*	*	*	*	*	*	*

**Table 10.** Allometric equations and calculated values for cranial and somatic proportions in *Cyclodomorphus melanops elongatus*. Values a and b solve the equation  $y = bx^a$ , r = correlation coefficient, s.e. = standard error of a,  $C_{41}$ ,  $C_{73}$  and  $C_{125}$  are calculated percentage proportions (y/x) at SVL = 41, 73 and 125 mm (minimum, minimum mature and maximum size). Sample sizes are as for ratios.

y	x	a	b	r	s.e.	$C_{41}$	$C_{73}$	$C_{125}$
AGL	SVL	1.1407	0.342	0.9869	0.0095	57.7	62.5	67.5
TL	SVL	1.2240	0.354	0.9769	0.0200	81.3	92.6	104.4
FLL	SVL	0.5862	1.022	0.8344	0.0196	22.0	17.3	13.9
HLL	SVL	0.6674	0.928	0.8777	0.0185	27.0	22.3	18.6
FLL	HLL	0.8832	1.077	0.9558	0.0138	81.3	77.8	74.6
HL	SVL	0.6037	0.885	0.9243	0.0126	20.3	16.2	13.1
HW	HL	1.0878	0.581	0.9547	0.0172	70.0	72.2	74.2
HD	HL	1.0949	0.438	0.9229	0.0231	53.6	55.4	57.1

**Table 11.** Sexual dimorphism in cranial and somatic proportions in *Cyclodomorphus melanops elongatus*. Tests of significance (i) and allometric and calculated values for males (ii) and females (iii) in sexually dimorphic characters. Conventions for (ii) and (iii) as for Table 3.  $C_{73}$  and  $C_{111}$  are calculated proportions at SVL = 73, 111 mm (mean minimum size at maturity, and maximum size for males, the smaller sex).

(i)

y	x	Slopes			Intercepts		
		F	d.f.	P	F	d.f.	P
AGL	SVL	0.019	1,318	n.s.	31.845	1,319	***
TL	SVL	11.003	1,137	***	—	—	—
FLL	SVL	3.996	1,323	*	45.313	1,324	***
HLL	SVL	2.465	1,319	n.s.	77.910	1,320	***
FLL	HLL	2.159	1,318	n.s.	0.168	1,319	n.s.
HL	SVL	2.677	1,318	n.s.	63.412	1,319	***
HW	HL	0.765	1,319	n.s.	0.174	1,320	n.s.
HD	HL	0.118	1,318	n.s.	0.173	1,319	n.s.

(ii)

y	x	a	b	r	s.e.	n	$C_{73}$	$C_{111}$
AGL	SVL	1.099	0.405	0.981	0.018	152	61.9	64.6
TL	SVL	1.261	0.312	0.980	0.031	72	95.6	106.7
FLL	SVL	0.663	0.750	0.830	0.036	156	17.7	15.3
HLL	SVL	0.733	0.722	0.882	0.032	153	23.0	20.5
HL	SVL	0.685	0.631	0.915	0.025	152	16.3	14.3

(iii)

AGL	SVL	1.103	0.409	0.979	0.018	170	63.6	66.4
TL	SVL	1.093	0.620	0.956	0.041	69	92.4	96.1
FLL	SVL	0.562	1.102	0.772	0.036	171	16.8	14.0
HLL	SVL	0.661	0.922	0.839	0.033	170	21.5	18.7
HL	SVL	0.633	0.757	0.925	0.020	139	15.7	13.4

**Table 12.** Allometric equations and calculated values for cranial and somatic proportions in *Cyclodomorphus melanops siticulosus*. Values a and b solve the equation  $y = bx^a$ , r = correlation coefficient, s.e. = standard error of a,  $C_{70}$  and  $C_{94}$  are calculated percentage proportions (y/x) at SVL = 70 and 94 mm (small adult and maximum size). Due to the narrow range of SVLs for the material known, small samples and the sexual dimorphism at this size, most correlations were non-significant in the pooled sample. Hence, this table presents only the allometric equations for males for all variables except AGL.

y	x	a	b	r	s.e.	$C_{70}$	$C_{94}$
AGL	SVL	1.3000	0.157	0.9168	0.2141	56.2	61.4
FLL	SVL	0.8482	0.390	0.8928	0.2140	20.5	19.6
HLL	SVL	0.6753	1.041	0.9168	0.1471	26.2	23.8
FLL	HLL	1.1440	0.519	0.8870	0.2978	78.9	81.2
HL	SVL	0.8756	0.323	0.9887	0.0665	19.0	18.4
HW	HL	0.8279	1.138	0.8567	0.2493	72.9	69.7
HD	HL	0.7712	1.014	0.8805	0.2076	56.1	52.9

**Table 13.** Allometric equations and calculated values for cranial and somatic proportions in *Cyclodomorphus venustus*. Values a and b solve the equation  $y = bx^a$ , r = correlation coefficient, s.e. = standard error of a,  $C_{40}$ ,  $C_{74}$  and  $C_{101}$  are calculated percentage proportions (y/x) at SVL = 40, 74 and 101 mm (minimum, minimum mature and maximum size). Sample sizes are as for ratios.

y	x	a	b	r	s.e.	$C_{40}$	$C_{74}$	$C_{101}$
AGL	SVL	1.1396	0.320	0.9819	0.0357	53.6	58.4	60.9
TL	SVL	1.1017	0.462	0.9323	0.0780	67.2	71.6	74.6
FLL	SVL	0.5781	1.163	0.7450	0.0840	24.5	18.9	16.6
HLL	SVL	0.7287	0.724	0.8943	0.0592	26.6	22.5	20.7
FLL	HLL	0.8147	1.415	0.8556	0.0800	91.3	84.0	80.6
HL	SVL	0.6647	0.778	0.9120	0.0485	22.6	18.4	16.6
HW	HL	0.9817	0.734	0.9278	0.0640	70.5	70.0	69.7
HD	HL	1.0740	0.432	0.9040	0.0824	50.8	52.4	53.2

**Table 14.** Sexual dimorphism in cranial and somatic proportions in *Cyclodomorphus venustus*. Tests of significance (i) and allometric and calculated values for males (ii) and females (iii) in sexually dimorphic characters. Conventions for (ii) and (iii) as for Table 3.  $C_{77}$  and  $C_{98}$  are calculated proportions at SVL = 77, 98 mm (mean minimum size at maturity, and maximum size for females, the smaller sex). TL and FLL were not significantly correlated with SVL in females due to the small size range of the female sample.

(i)

y	x	Slopes			Intercepts		
		F	d.f.	P	F	d.f.	P
AGL	SVL	2.477	1,26	n.s.	5.762	1,27	*
HLL	SVL	3.774	1,26	n.s.	20.190	1,27	***
HL	SVL	14.710	1,26	***	—	—	—
HW	HL	0.273	1,26	n.s.	2.475	1,27	n.s.
HD	HL	0.217	1,26	n.s.	6.240	1,27	*

(ii)

y	x	a	b	r	s.e.	n	$C_{77}$	$C_{98}$
AGL	SVL	0.994	0.588	0.993	0.047	8	57.3	57.2
HLL	SVL	0.883	0.399	0.969	0.092	8	24.0	23.3
HL	SVL	0.892	0.312	0.979	0.076	8	19.5	19.0
HD	HL	0.891	0.677	0.989	0.055	8	50.4	49.2

(iii)

AGL	SVL	1.206	0.243	0.908	0.124	22	59.5	62.5
HLL	SVL	0.554	1.514	0.655	0.143	22	21.8	19.6
HL	SVL	0.439	2.048	0.727	0.093	22	17.9	15.6
HD	HL	1.033	0.497	0.591	0.316	22	54.2	54.4



## Three New Species of Australian Fishes of the Genus *Plectranthias* (Perciformes: Serranidae: Anthiinae)

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**Abstract.** Three new species of anthiine fishes of the genus *Plectranthias* are described from Australian waters: *P. robertsi* from 220–400 m off Queensland at 18–23°S is distinctive in having 15 dorsal soft rays, 16 pectoral rays, 32–35 lateral-line scales, filamentous upper caudal rays (easily broken) and extremely prolonged second dorsal and second pelvic rays in the male; *P. pallidus*, represented by a single specimen taken in 220 m off Townsville, is characterised by 16 dorsal soft rays, 13 pectoral rays, 28 lateral-line scales, 2 retrorse spines on the ventral margin of the preopercle, and the third dorsal spine longest, 2.0 in head length; and *P. lasti* from a specimen off Marion Reef, Queensland in 365–370 m and one from the Northwest Shelf in 202 m, is distinguished by having 14 dorsal soft rays, 15 pectoral rays, 30 lateral-line scales, no serrae on the preopercular margin, and a body depth 3.05 in SL.

RANDALL, JOHN E. & DOUGLASS F. HOESE, 1995. Three new species of Australian fishes of the genus *Plectranthias* (Perciformes: Serranidae: Anthiinae). Records of the Australian Museum 47(3): 327–335.

The anthiine fish genus *Plectranthias* is represented mainly by species that occur at greater depths than normally explored by SCUBA divers. Because of the small size of most of these fishes, they have little or no commercial value. As a result, few specimens have found their way to museums.

Randall (1980) revised the genus; he placed *Sayonara*, *Isobuna*, *Xenanthias*, *Pteranthias*, *Zalanthias*, *Serranops*, *Pelontrus*, and *Zacallanthias* in the synonymy of *Plectranthias*. He recognised 30 species, of which 13 were described as new. He noted that 18 of the 30 species

are known from only one or two collections, and eight of these are represented by single specimens. He remarked that his revision must be considered as preliminary because the lack of material of many species precluded the detailed study of internal anatomy and because he expected more undescribed species to be discovered.

Since Randall's revision, the following eleven species have been described as new: *P. randalli* Fourmanoir & Rivaton, 1980; *P. altipinnatus* Katayama & Masuda, 1980; *P. maculatus* Fourmanoir, 1982; *P. barroi* Fourmanoir, 1982; *P. rubromaculatus* (Borets, 1982), a

junior synonym of *P. kelloggi* (Jordan & Evermann); *P. fijiensis* Raj & Seeto, 1983; *P. exsul* Heemstra & Anderson, 1983; *P. chungchowensis* Shen & Lin, 1984 (Lee, 1990, however, placed it in the synonymy of *P. whiteheadi* Randall); *P. bilaticlavia* Paulin & Roberts, 1987; *P. parini* Anderson & Randall, 1991; and *P. pelicierei* Randall & Shimizu, 1994.

In the present paper we describe three more species of the genus, all taken by trawling on the continental shelf of Australia. Methods of counting and measuring of specimens follow Randall (1980). In the descriptions below, data in parentheses apply to paratypes.

Nine additional new species from outside Australian seas remain to be described. When all are named, the senior author will prepare a key.

### Material and methods

Type specimens have been deposited in the Australian Museum, Sydney (AMS); Bernice P. Bishop Museum, Honolulu (BPBM); CSIRO Division of Fisheries, Hobart (CSIRO H); Northern Territory Museum, Darwin (NTM); Queensland Museum, Brisbane (QM); and the U.S. National Museum of Natural History, Washington, D.C. (USNM). Lengths given in the listing of type material are standard length (SL). Proportional measurements in the text are rounded to the nearest 0.05.

### *Plectranthias robertsi* n.sp.

Fig. 1, Table 1

**Holotype:** AMS I.20968-003, female, 89.5 mm, Australia, Queensland, E of Hinchinbrook Island (18°25'S), 320–356 m, prawn trawl, personnel of Australian Museum and Australian Institute of Marine Science, 27 February 1979.

**Paratypes:** QM 20024, 78.4 mm, Australia, Queensland, Capricorn Channel, 22°51.7'S 152°45.7'E, 261 m, trawl, RV *Craigmin*, 3 October 1980; CSIRO H719-12-17, 6: 108–125 mm, Queensland, Capricorn Channel, SE of Swain Reefs (22°56'7"S 153°0'8"E), 325–338 m, mud bottom, scampi net, RV *Soela* Station 506-85-12, 18 November 1985; CSIRO H690-01, 3: 70–89 mm, Queensland, W of Saumarez Reef (21°33'4"S 152°58'4"E), 239–247 m, RV *Soela* Station 6-85-19, 28 November 1985; CSIRO H682-01, 81.5 mm, Queensland, E of Dunk Island (17°57'7"S 147°1', 6'E), 250–252 m, RV *Soela* Station 6-85-44, J. Stevens, 29 November 1985; CSIRO H691-01, 82 mm, E of Dunk Island (17°59'1"S 147°9'6"E), 400 m, scampi net, RV *Soela*, Station 6-85-47, J. Stevens, 29 November 1985; AMS I.25800-007, 6: 60.6–115 mm, off Townsville, 17°58'30"S 147°0'30"E, 220 m, bottom trawl, RV *Soela*, M. McGrouther, S. Reader, and H. Larson, 8 January 1986; BPBM 35053, 93.4 mm, NTM S.11746-028, 5: 70.5–112 mm, USNM 319773, 2: 64.5–97.3 mm, same data as

preceding; AMS I.25801-013, 2: 54.4–74.3 mm, NTM S.11747-023, 5: 74–104 mm, same location, 9 January 1986.

**Diagnosis.** Dorsal rays X,15; pectoral rays 16; lateral-line complete, the pored scales 32–34; scales above lateral line to origin of dorsal fin 3; scales dorsally on head extending to posterior nostrils; scales present on maxilla; body depth 2.6–3.2 in SL; margin of preopercle finely serrate, without antrorse spines on ventral edge; fourth or fifth dorsal spine longest, 2.6–3.1 in SL; second dorsal soft ray longest, prolonged as a filament in males; second pelvic soft ray longest, greatly prolonged as a filament in males; caudal fin emarginate, the second to fourth branched rays filamentous (but easily broken); pale in alcohol with a blackish spot on first four or five lateral-line scales and adjacent scales of the row above.

**Description.** Dorsal rays X,15 (all rays branched, the last to base); anal rays III,7 (all rays branched, the last to base); pectoral rays 16 (one of 15 paratypes with 15 rays on one side; uppermost and lower four to eight rays simple); pelvic rays I,5; branched caudal rays 8+7; upper and lower simple segmented caudal rays 3; upper and lower procurent caudal rays 4; lateral line complete, the pored scales 33–34 (32–35, only one of 15 paratypes with 32 and one with 35); scales above lateral line to origin of dorsal fin 3; scales below lateral line to origin of anal fin 10 (9½–10); circumpeduncular scales 15; diagonal rows of scales on cheek 7; gill rakers 6+14 (6–7+13–14, usually 6+14; 3+12 in holotype developed, i.e. higher than width of base); pseudobranchial filaments 23 (18–27); branchiostegal rays 7; vertebrae 10+16; supraneural (predorsal) bones 2, the arrangement with neural spines and anterior dorsal spines and pterygiophores as follows: 0/0/2/1+1/1/1/ (where 0 is a supraneural bone, / a neural spine, and numerals dorsal spines—after Ahlstrom *et al.*, 1976).

Body moderately deep, the depth 2.75 (2.6–3.2) in SL, and compressed, the width 1.95 (1.8–2.3) in depth; head pointed, the lower jaw slightly projecting; dorsal profile of head nearly straight, becoming convex on nape; head length 2.35 (2.3–2.4) in SL; snout length 4.15 (3.95–4.6) in head; fleshy orbit diameter 3.5 (3.25–3.85) in head; interorbital space flat, the least bony width 7.05 (5.2–7.8) in head; least depth of caudal peduncle 3.2 (3.15–3.6) in head; caudal peduncle length 2.25 (2.15–2.45) in head.

Mouth large, the maxilla reaching to or posterior to a vertical at rear edge of pupil of eye, the upper jaw length 1.95 (1.8–2.0) in head; mouth oblique, the gape forming an angle of about 30° to horizontal axis of body; a very small, splint-like supramaxilla posteriorly on maxilla; upper jaw with a band of villiform teeth, becoming broader anteriorly, the teeth in inner and outer rows toward front of jaw progressively larger medially, those immediately adjacent to symphysis slender and inwardly depressible; a narrow area without teeth at symphysis; a pair of small stout incurved canine teeth anteriorly in upper jaw separated by a gap about equal

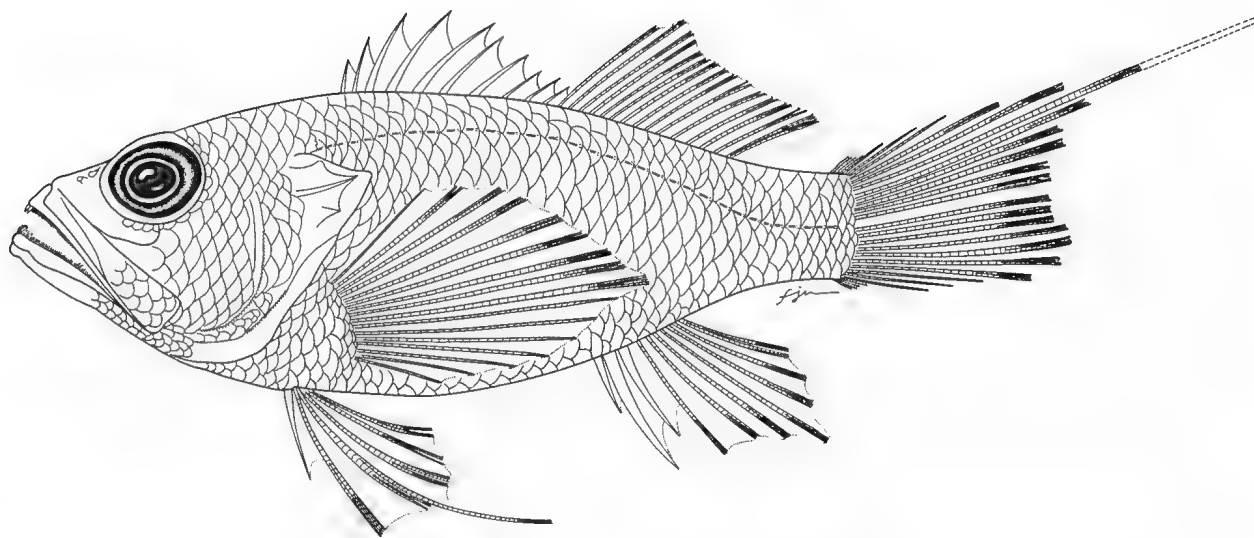


Fig. 1. Holotype of *Plectranthias robertsi*, AMS I.20968-003, 78.4 mm, female, colour pattern not shown.

to one-third orbit diameter (in some specimens there may be two close-set canines in place of a single canine); lower jaw with small conical teeth in two rows for most of jaw, expanding to five rows at adjacent to symphysis; the longest tooth a small slightly recurved canine on midside of jaw; a narrow gap with no teeth at symphysis; a V-shaped band of very small conical teeth in two rows on vomer; a narrow band of very small conical teeth in one to two rows on palatines. Tongue triangular, the pointed tip slightly rounded. Longest gill raker on first gill arch at angle, its length one-half orbit diameter and about twice length of longest gill filaments.

Opercle with three flat spines, the middle one largest and terminating most posteriorly, at level of upper edge of pupil, slightly upcurved, and closer to lower than upper spine; upper spine most anteriorly terminating, poorly developed, flexible, dorsal and posterior margin forming an angle of about 90°; lower spine acute and sharp; opercular flap well developed and pointing diagonally upward; margin of preopercle serrate, the serrae 41 in holotype (varying from 24 in a 54.4 mm paratype to 57 in a 115 mm one); no antrorse spines on ventral margin of preopercle; margin of subopercle and upper part of interopercle serrate (12 serrae on subopercle and 9 on interopercle of holotype); suprascapular serrae 3 (1–6).

Nostrils in front of upper fourth of eye, the anterior in a short membranous tube which is about three times higher posteriorly; posterior nostril ovate with a slight rim, about twice diameter of anterior nostril; internarial space about equal to diameter of posterior nostril; posterior nostril separated from edge of orbit by a distance slightly greater than nostril diameter.

Lateral line broadly arched over pectoral fin, approximately following dorsal contour of body from sixth scale on; scales finely ctenoid; scales dorsally on

head extending to posterior nostrils; scales on suborbital extending to below anterior part of eye; maxilla scaled; scales on posterior half of lower jaw, none on rest of chin; a series of four fossae on anterior naked part of lower jaw, each covered by a membrane bearing a few small pores; small scales basally on all fins, variously lost.

Origin of dorsal fin above third lateral-line scale; first dorsal spine 7.2 (6.55–7.4) in head, about 1.4 in length of second spine; fourth or fifth dorsal spines longest, 2.95 (2.6–3.1) in head; last dorsal spine 7.6 (7.3–8.55) in head; second dorsal soft ray longest, greatly prolonged in males, 4.85 (2.55–5.6) in SL; origin of anal fin below base of fifth dorsal soft ray; first anal spine 5.35 (5.0–5.5) in head; second anal spine 2.5 (2.3–2.65) in head; third anal spine 3.15 (2.85–3.3) in head; second or third anal soft ray longest, 1.85 (1.55–2.0) in head; caudal fin emarginate, the second to fourth rays filamentous, the third ray longest, 1.9 in SL (broken on all paratypes; intact only on photograph of holotype); ninth pectoral ray longest, 2.6 (2.5–2.7) in SL; origin of pelvic fins anterior to base of pectorals, in vertical alignment with upper end of gill opening; second pelvic ray longest (prolonged in males; when intact, extending beyond base of anal fin), 3.3 (1.45–3.3) in SL.

Colour of holotype in alcohol: pale except for dusky pigment on first four lateral-line scales and to a lesser extent on adjacent scales of the row above (this dark blotch is larger and more heavily pigmented on most of the larger paratypes; in addition, those paratypes over about 95 mm SL have the tips of the caudal rays broadly blackish).

Colour of holotype from a Kodachrome transparency: tan, becoming silvery white over abdomen and thorax, with some silvery iridescence on opercle; first four lateral-line scales dusky, with some dark pigment on



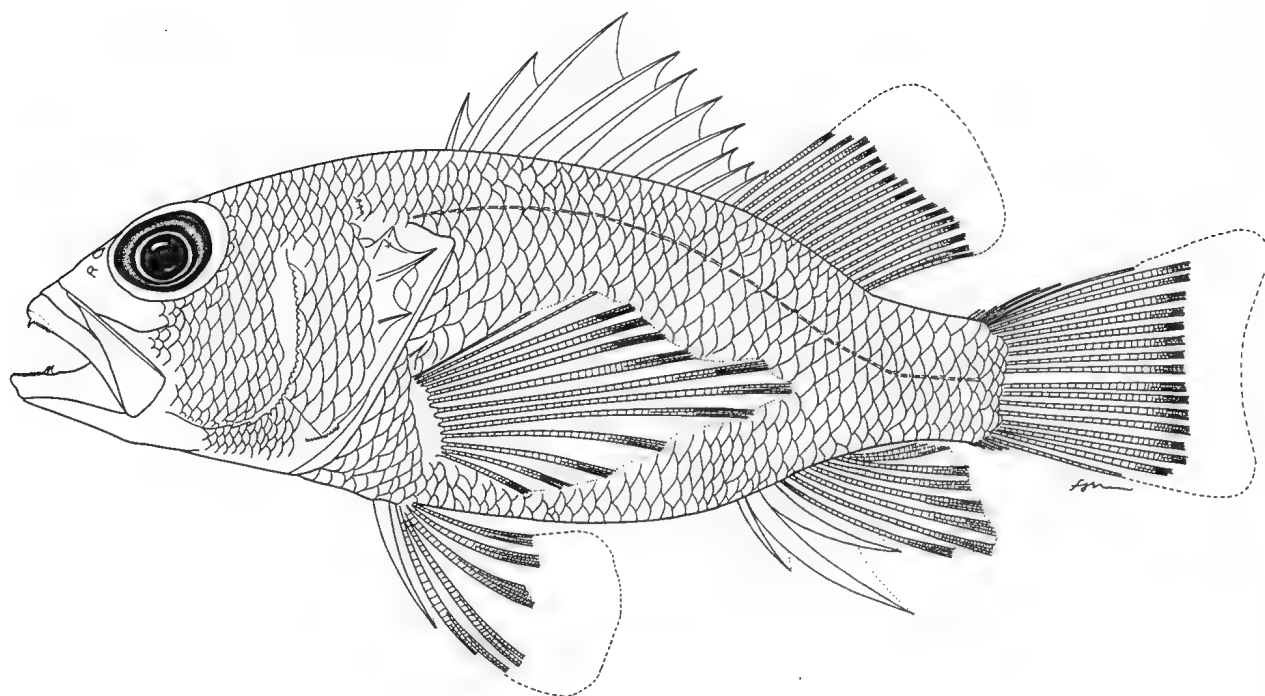


Fig. 2. Holotype of *Plectranthias pallidus*, AMS I.25800-005, 76.0 mm SL, female.

adjacent scales above; a faint narrow yellow stripe extending from eye to anterior lateral line; some indistinct faint yellow to yellow-orange blotches of about pupil size barely detectable on the photograph, one series of about four dorsally on body at base of dorsal fin and a second series along side of body; snout dusky yellowish, the upper lip more yellow; lower jaw dusky orangish, this colouration more intense anteriorly; median fins pale yellowish (more yellow on the dorsal than the anal and caudal); paired fins whitish; iris a mixture of yellow and blackish.

**Remarks.** We name this fish *robertsi* in honour of Clive D. Roberts who first recognised it as an undescribed species from a single specimen taken in Capricorn Channel off Queensland and had plans to name it when more material was collected. When he heard of our research on the species, he kindly made his specimen available to us.

All our specimens were collected by trawling off the coast of Queensland from 18–23° S in the depth range of 220–400 m.

This species is most distinctive in the greatly prolonged second dorsal and second pelvic soft rays of males and in the filamentous caudal rays of both sexes. Unfortunately, these elongate rays are easily broken, especially on specimens taken by trawling. In fact, the longest caudal ray, the lower branch of the third branched ray, is broken on all of our specimens.

It is intact only in the photograph of the holotype, thus the caudal-fin length is given only for this specimen in Table 1.

Of the known species of *Plectranthias*, *P. robertsi* seems most closely related to *P. maculicauda* (Regan), known from New Zealand and New South Wales. The two have the same dorsal ray, lateral-line scale, and cheek-scale counts, no retrorse spines on the finely serrate preopercular margin, about the same body depth, a prolonged second dorsal ray, and a filamentous upper caudal ray. *Plectranthias maculicauda* differs in having modally 15 pectoral rays, 15–17 lower-limb gill rakers, and a prominent oval black spot posteriorly on the upper side of the caudal peduncle.

### *Plectranthias pallidus* n.sp.

Fig. 2, Table 2

**Holotype:** AMS I.25800-005, female, 76.0 mm, Australia, Queensland, off Townsville, 17°58'30"S 147°0'30"E, 220 m, bottom trawl, RV *Soela*, M. McGrouther and S. Reader, 8 January 1986.

**Diagnosis.** Dorsal rays X,16; pectoral rays 13, all but upper two branched; lateral-line complete, the pored scales 28; scales above lateral line to origin of dorsal

fin 3; scales dorsally on head extending to posterior nostrils; no scales on maxilla or chin; body depth 2.75 in SL; posterior margin of preopercle serrate; ventral margin of preopercle with 2 antrorse spines; third dorsal spine longest, 2.0 in head; caudal fin slightly emarginate; colour in alcohol entirely pale.

**Description.** Dorsal rays X,16 (all rays branched); anal rays III,7 (all rays branched, the last to base); pectoral rays 13 (both sides counted; all but upper two branched); pelvic rays I,5; branched caudal rays 8+7; upper segmented simple caudal rays 3 (medial upper ray about three-fourths length of adjacent branched ray), lower segmented simple caudal rays 2 (medial lower ray about half length of adjacent branched ray); upper and lower procurent caudal rays 5; lateral line complete, the pored scales 28 (not counting a single pored scale diagonally above and anterior to first lateral-line scale); scales above lateral line to origin of dorsal fin 3; scales below lateral line to origin of anal fin 11; circumpeduncular scales 14; diagonal rows of scales on cheek 6; gill rakers 5+11 (2+8 developed); pseudobranchial filaments 21; branchiostegal rays 7; vertebrae 10+16; supraneural (predorsal) bones 3, their arrangement with neural spines and anterior dorsal-fin spines and pterygiophores as follows: 0/0+0/2/1+1/1/1 (where 0 is a supraneural bone, / is a neural spine, and numerals are dorsal spines—after Ahlstrom *et al.*, 1976).

Body moderately deep, the depth 2.75 in SL, and somewhat compressed, the width 1.8 in depth; head pointed, the lower jaw slightly projecting; dorsal profile of head only slightly convex; head length 2.3 in SL; snout length 4.25 in head; fleshy orbit diameter 4.4 in head; interorbital space flat, the least bony width 11.2 in head; least depth of caudal peduncle 3.7 in head; caudal peduncle length 2.8 in head.

Mouth moderately large, the maxilla reaching slightly posterior to a vertical at centre of eye, the upper jaw length 2.2 in head; a very small, splint-like supramaxilla posteriorly on maxilla; mouth oblique, the gape forming an angle of about 25° to horizontal axis of body; a pair of strong incurved canine teeth anteriorly in upper jaw (double on one side) separated by a gap about equal to half orbit diameter; rest of jaw with a band of villiform teeth, broadest anteriorly, a narrow gap with no teeth anteriorly at symphysis, immediately to side of midline a few teeth in the inner row of band enlarged, slender and inwardly depressible; a close-set pair of strong slightly recurved canine teeth about half way back in lower jaw; a band of villiform teeth in lower jaw, broadest anteriorly, without any enlarged teeth; teeth on two sides of jaw contiguous at symphysis; a V-shaped band of villiform teeth on vomer in three irregular rows; a narrow band of villiform teeth on palatines in two to three irregular rows. Tongue pointed.

Three prominent flat spines on opercle, the upper smallest and terminating most anteriorly, the middle one terminating most posteriorly, projecting dorsally at an angle of nearly 45° with body axis, its tip closer to upper than lower spine; opercular flap well developed and also

pointing diagonally upward; posterior margin of preopercle with 27 serrae (29 on other side); ventral margin of preopercle with two antrorse spines, the one nearest angle with two serrae on its lower edge; margin of subopercle and interopercle each with six small serrae adjacent to their juncture; free edge of supracleithrum with four serrae.

Anterior nostril in a membranous tube with an elevated posterior flap in front of upper edge of pupil; posterior nostril diagonally above and behind anterior nostril, its aperture partially restricted by membrane.

Lateral line broadly arched over pectoral fin, gradually descending to an almost straight portion of five scales on posterior half of caudal peduncle; all scales finely ctenoid; head scaled except for snout, suborbital region below anterior third of eye, chin, branchiostegal rays, and opercular flap; small scales basally on median fins, but too many missing to determine extent of squamation.

Origin of dorsal fin above second lateral-line scale; first dorsal spine 5.3 in head; second dorsal spine nearly twice length of first, 1.6 in length of third; third dorsal spine longest, 2.0 in head; last dorsal spine 4.6 in head; no dorsal soft rays prolonged, the third longest, 1.95 in head; origin of anal fin below base of fifth dorsal soft ray; first anal spine 4.0 in head; second anal spine longest, 2.0 in head; third anal spine 2.5 in head; second anal soft ray longest, 1.95 in head; caudal fin slightly emarginate, its length 1.65 in head, the caudal concavity 10.4 in head; pectoral fins pointed, the eighth ray longest, extending slightly posterior to a vertical at base of third anal spine, the fin length 1.25 in head; origin of pelvic fins slightly anterior to base of pectoral fins, on line with a vertical at upper end of gill opening; length of pelvic fins 1.85 in head.

Colour in alcohol entirely pale. Life colour unknown.

**Remarks.** This species is named *Plectranthias pallidus* from the Latin for pale, in reference to the overall pale colouration. It is described from only a single specimen collected off Townsville, Queensland in 220 m.

*Plectranthias pallidus* appears to be closely related to *P. wheeleri* Randall, known from two specimens from Indonesia. The two species share the same number of dorsal soft rays, the low count of 13 pectoral rays, nearly the same lateral-line scales (28 vs. 29), the same number of cheek scales, the same number of gill rakers, 2 retrorse spines on the ventral margin of the preopercle, essentially the same dentition, and similarity in many proportional measurements. They differ in *pallidus* being slightly more elongate (depth 2.75 in SL, compared to 2.6–2.65 for *wheeleri*), having longer dorsal and anal spines, the third dorsal spine 2.0 in head of *pallidus* (2.35–2.45 in *wheeleri*), longer caudal fin (1.6 in head of *pallidus*, compared to 1.85–1.9 for *wheeleri*), and longer pelvic fins (1.75 in head of *pallidus*, compared to 1.95–2.0 for *wheeleri*). In addition, *P. wheeleri* has some dark markings in preservative, whereas there is no trace of them in *pallidus*.

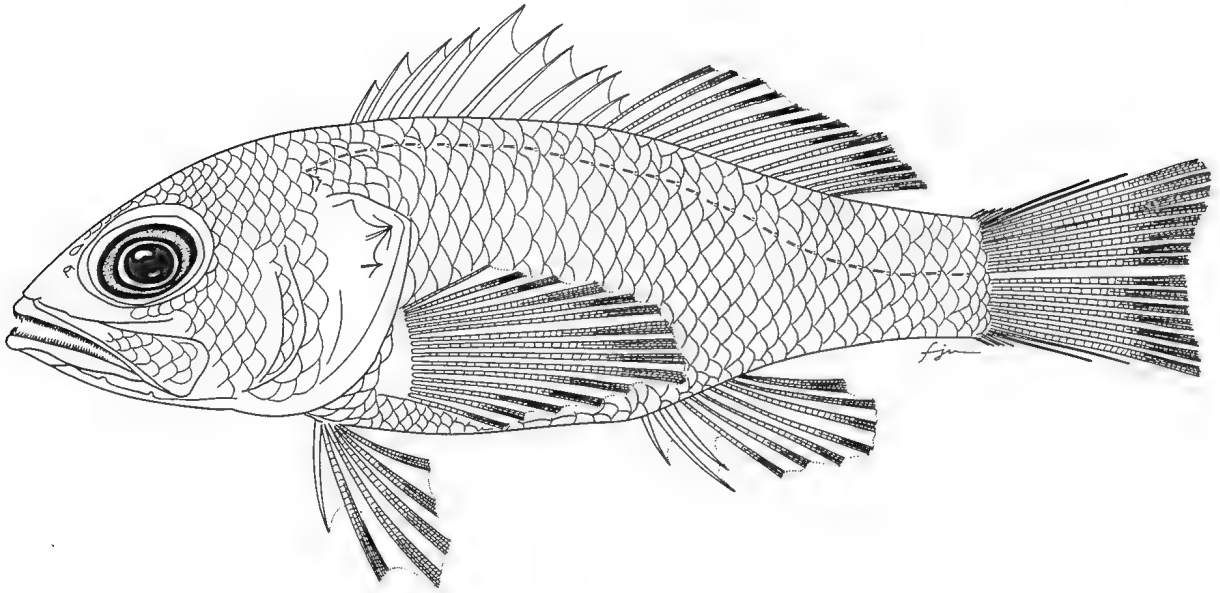


Fig. 3. Holotype of *Plectranthias lasti*, CSIRO H651-02, 68 mm, male.

*Plectranthias lasti* n.sp.

Fig. 3, Table 3

**Holotype:** AMS I.22807-056, male, 49.2 mm, Western Australia, Northwest Shelf, 175 km N of Port Hedland, 18°32'S 118°17'E, 200–204 m, Engel trawl, RV *Soela*, J.R. Paxton, 2 April 1982.

**Paratype:** CSIRO H651-02, male, 68.0 mm, Queensland, NE continental slope S of Marion Reef, 19°44'S 152°6'E, 365–370 m, trawl, RV *Soela* Station 6-85-32, P.R. Last, 23 November 1985.

**Diagnosis.** Dorsal rays X,14; pectoral rays 15 (all except uppermost branched); lateral-line complete, the pored scales 30; scales above lateral-line to origin of dorsal fin 2; scales dorsally on head extending to posterior nostrils; scales present on maxilla; body depth 3.05 in SL; margin of preopercle smooth; fifth dorsal spine longest, 2.9–3.0 in head; caudal fin emarginate; colour in alcohol pale, without dark markings.

**Description.** Dorsal rays X,14 (all rays branched, the last to base); anal rays III,7 (all rays branched); pectoral rays 15 (all rays branched except uppermost); pelvic rays I,5; branched caudal rays 8+7; upper and lower segmented simple caudal rays 2; upper procurrent caudal rays 5; lower procurrent caudal rays 4; lateral-line complete, the pored scales 30; scales above lateral line to origin of dorsal fin 2; scales below lateral line to origin of anal

fin 8½; circumpeduncular scales 12; diagonal rows of scales on cheek 6; gill rakers 5+12 (1+7 developed); pseudobranchial filaments 15 (17); branchiostegal rays 7; vertebrae 10+16; supraneural (predorsal) bones 2, their arrangement with neural spines and dorsal spines and pterygiophores is the same as found in *P. robertsi*.

Body moderately elongate, the depth 3.05 in SL, and compressed, the width 1.65 (1.6) in depth; head somewhat pointed, the lower jaw slightly projecting; dorsal profile of head smoothly convex; head length 2.35 in SL; snout length 4.95 (4.85) in head; fleshy orbit diameter 3.3 (4.0) in head; interorbital space flat, the least bony width 10.7 (9.65) in head; least depth of caudal peduncle 3.15 in head; caudal peduncle length 2.05 in head.

Mouth large, the maxilla nearly or just reaching a vertical at posterior edge of orbit, the upper jaw length 2.0 in head length; a very small, splint-like supramaxilla posteriorly on maxilla; mouth oblique, the gape forming an angle of about 25° to horizontal axis of body; an incurved canine tooth on each side at front of upper jaw separated by a symphyseal gap without teeth contained 2.7 times in orbit diameter; a band of villiform teeth in upper jaw which broadens anteriorly, the inner teeth near symphysis enlarged and inwardly depressible, one on each side longer than upper canines, a narrow gap at symphysis without teeth; posterior half of lower jaw with a narrow band of medially depressible conical teeth in three rows, those of outer very small, those of inner row much the largest; a fixed recurved canine tooth in outer row at midside of lower jaw; anterior to it two rows of inwardly depressible slender conical teeth of moderate size, these two rows gradually broadening anteriorly to as many as four or five rows adjacent

symphysis; teeth bands on two sides of lower jaw almost contiguous; lower jaw teeth becoming smaller near symphysis except one on each side in inner row enlarged and recumbent and a stout short canine in outer row; upper and lower canine teeth less developed on paratype; vomer with a V-shaped band of villiform teeth in two to three irregular rows; palatines with a narrow band of villiform teeth in two to three irregular rows. Tongue narrowly triangular with a slightly rounded tip. Longest gill raker on first gill arch the first on lower limb adjacent to raker at angle, its length one-half orbit diameter and nearly twice length of longest gill filaments on first arch.

Three flat spines posteriorly on opercle, the middle one largest and terminating most posteriorly, curving upward, its sharp tip at level of upper edge of pupil, closer to lower than upper spine; upper spine terminating most anteriorly, not pungent, posterior and dorsal margin forming an angle of about 90°; lower spine very acute and sharp; margin of preopercle, subopercle, and interopercle smooth; free margin of suprascapula partially covered by scales and not serrate (one minute spine); opercular flap well developed and angling upward in alignment with middle opercular spine.

Anterior nostril in a thin moderately long membranous tube, somewhat higher posteriorly, in front of upper edge of pupil; posterior nostril posterodorsal to anterior nostril, its ovate opening nearly twice as large as anterior nostril, separated from edge of orbit by a distance only slightly greater than nostril diameter; internarial space containing a large pore. Pores of lateralis system on head prominent, especially the five of mandibular series and the suborbital series.

Lateral line broadly arched over pectoral region, its upper part following contour of back; scales finely ctenoid; scales dorsally on head extending anteriorly to posterior nostrils; scales in suborbital region extending to below middle of orbit in holotype (unless some anterior scales are missing), and to below front of orbit in paratype; maxilla scaled; no scales on snout, lower jaw, chin, and gill membranes; small scales basally on all fins except spinous portions of dorsal and anal fins, full extent of squamation not known due to loss of scales.

Origin of dorsal fin over third lateral-line scale; first dorsal spine 7.8 (7.6) in head; second dorsal spine nearly twice as long as first; fifth dorsal spine longest, 3.0 (2.9) in head; last dorsal spine 6.4 (6.05) in head; ninth dorsal soft ray longest, 2.3 (2.4) in head; origin of anal fin below base of third dorsal soft ray; first anal spine 5.2 (5.0) in head; second anal spine 2.95 (2.9) in head; third anal spine 3.65 in head; fourth anal soft ray longest, 1.95 (2.05) in head; caudal fin broken in both specimens but seems to have been emarginate; ninth and tenth pectoral rays longest, 1.3 in head; origin of pelvic fins slightly anterior to a vertical line from upper end of gill opening; second pelvic ray longest, 1.8 in head.

Colour in alcohol uniformly pale. Colour in life unknown.

**Remarks.** This species is named *Plectranthias lasti* in honour of Peter R. Last who collected the paratype, recognised it as undescribed, and made the CSIRO specimen available to us.

Our two specimens have come from widely separated localities in Australia, one off Marion Reef, Queensland, and the other from the Northwest Shelf of Western Australia. They were collected by trawling in the depth range of 202–370 m. The bottom temperature for the station on the Northwest Shelf was 16.0–16.6°C.

*Plectranthias lasti* is clearly a close relative of *P. megalophthalmus* Fourmanoir & Randall, known from a single 61.8 mm specimen taken by a trap in 200 m off NW New Caledonia, and *P. fijiensis* Raj & Seeto, 1983 described from one 74.7 mm specimen collected by trap in 293 m off the Suva barrier reef, Viti Levu. *Plectranthias lasti* and *P. megalophthalmus* share the same pectoral-ray, and gill-raker counts, nearly the same lateral-line scale counts (30 vs. 31), smooth-edged preopercular, subopercular, and interopercular bones, similar dentition, similar squamation of the head, and the presence of a large pore between the anterior and posterior nostrils. *Plectranthias lasti* differs in having 15 instead of 14 dorsal soft rays, a deeper body (depth 3.05 in SL, compared to 3.4 for *megalophthalmus*), and smaller eye (4.0 in head of 68 mm paratype of *lasti*, compared to 2.9 for the 61.8 mm *megalophthalmus*). *Plectranthias lasti* and *P. fijiensis* also have many characters in common, including the same pectoral-ray and gill-raker counts, smooth-edged opercular bones, and essentially the same dentition and head squamation. They differ in the dorsal soft ray count (14 for *lasti*, 15 for *fijiensis*), lateral-line scale count (30 for *lasti*, 32 for *fijiensis*), body depth (3.05 in SL of *lasti*, 2.7 for *fijiensis*), and height of the longest dorsal spine (2.9–3.0 in head of *lasti*, 3.3 in *fijiensis*). In addition, the holotype of *fijiensis* is reported to have its ninth to twelfth pectoral rays unbranched, in addition to the first, whereas only the first is unbranched in *lasti*.

**ACKNOWLEDGMENTS.** We thank the CSIRO Division of Fisheries and Oceanography, Hobart, for providing many of the specimens of the new species of *Plectranthias* for our study, Helen K. Larson, Mark McGrouther and Clive D. Roberts for the loan of specimens, Francisco Neira and Tom Trnski for the drawings of the three holotypes, and Richard L. Pyle and Sally Reader for the radiographs.

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**Table 1.** Proportional measurements of selected type specimens of *Plectranthias robertsi* expressed as a percentage of the standard length.

	HOLOTYPE				PARATYPES				
	AMS I.20968 –003	AMS I.25801 –013	AMS I.25801 –013	CSIRO H682 –01	BPBM 35053	CSIRO H719 –13	AMS I.25800 –045	AMS I.25800 –007	CSIRO H719 –15
Sex	female	female	female	female	male	female	male	male	male
Standard length (mm)	89.5	54.4	74.3	81.5	93.4	108.0	111.0	115.0	125.0
Body depth	36.1	31.2	35.3	33.2	36.4	37.4	35.4	38.0	38.2
Body width	18.0	15.2	17.5	18.4	16.6	19.8	16.6	16.5	19.2
Head length	42.4	41.8	42.2	43.1	42.3	43.0	42.3	41.8	41.5
Snout length	10.2	9.2	9.2	9.8	10.1	10.7	10.3	10.4	10.5
Orbit diameter	12.1	12.9	13.0	12.9	11.6	11.1	11.9	11.4	10.9
Bony interorbital width	6.0	5.4	6.1	5.7	6.2	7.1	7.9	8.0	7.6
Upper jaw length	21.5	20.6	22.0	21.3	21.1	21.7	21.6	23.1	22.0
Caudal peduncle depth	13.3	12.5	12.9	12.0	13.4	13.0	13.5	13.3	13.1
Caudal peduncle length	18.7	19.0	19.5	18.7	17.1	18.9	17.1	17.0	17.5
Predorsal length	38.8	37.9	39.7	39.0	39.9	38.3	39.8	40.3	37.8
Preanal length	69.0	68.8	67.0	68.8	67.6	68.4	68.5	69.7	70.7
Prepelvic length	39.9	36.4	35.5	37.8	36.5	38.8	38.0	40.0	40.2
Dorsal fin base	48.2	48.5	52.4	48.1	50.8	50.5	48.3	50.9	50.0
First dorsal spine	5.9	6.4	6.4	6.1	6.3	5.8	6.3	6.2	5.9
Longest dorsal spine	14.3	16.0	15.5	15.9	14.2	14.1	14.5	14.3	13.5
Last dorsal spine	5.6	5.5	5.8	5.3	5.4	5.8	5.4	4.9	5.3
Longest dorsal ray	20.7	17.8	18.7	broken	35.2	25.5	broken	broken	39.3
Anal fin base	14.7	15.3	15.0	14.7	15.1	14.8	15.6	15.8	15.2
First anal spine	7.9	7.6	8.4	8.6	7.7	8.3	7.7	8.0	7.7
Second anal spine	16.8	18.4	18.0	18.1	17.2	16.6	15.9	15.8	16.1
Third anal spine	13.5	14.7	14.1	13.8	14.1	13.0	13.5	14.0	13.4
Longest anal ray	23.1	24.0	23.9	21.2	22.5	22.4	25.4	27.0	24.9
Longest caudal ray	broken	broken	52.2	broken	broken	broken	broken	broken	broken
Pectoral fin length	38.2	37.7	37.0	37.7	38.5	37.1	40.0	38.7	39.6
Pelvic spine length	15.0	15.7	16.1	15.3	15.2	15.4	13.8	15.2	14.8
Pelvic fin length	30.2	30.1	33.2	31.8	49.2	31.0	69.3	67.6	55.3

**Table 2.** Proportional measurements of holotype of *Plectranthias pallidus* expressed as a percentage of standard length.

	AMS I.25800-005
Standard length	76.0
Body depth	36.6
Body width	20.2
Head length	43.8
Snout length	10.5
Orbit diameter	10.0
Bony interorbital width	3.9
Upper jaw length	19.8
Caudal peduncle depth	11.9
Caudal peduncle length	15.5
Predorsal length	41.2
Preal anal length	73.8
Prepelvic length	40.7
Dorsal fin base	47.3
First dorsal spine	8.3
Longest dorsal spine	21.6
Tenth dorsal spine	9.5
Longest dorsal ray	18.4
Anal fin base	15.4
First anal spine	10.9
Second anal spine	22.0
Third anal spine	17.4
Longest anal ray	22.3
Caudal fin length	27.0
Caudal concavity	4.2
Pectoral fin length	35.6
Pelvic spine length	17.0
Pelvic fin length	23.9

**Table 3.** Proportional measurements of holotype and paratype of *Plectranthias lasti* expressed as a percentage of standard length.

	Holotype AMS I.22807-056	Paratype CSIRO H651-02
Standard length	49.2	68.0
Body depth	32.8	32.7
Body width	20.0	20.3
Head length	42.7	42.5
Snout length	8.6	8.8
Orbit diameter	12.8	10.6
Bony interorbital width	4.0	4.4
Upper jaw length	21.5	21.1
Caudal peduncle depth	13.6	13.4
Caudal peduncle length	20.8	20.9
Predorsal length	39.3	38.1
Preal anal length	66.3	65.7
Prepelvic length	36.0	35.2
Dorsal fin base	49.2	47.2
First dorsal spine	5.5	5.6
Longest dorsal spine	14.2	14.7
Tenth dorsal spine	6.7	7.0
Longest dorsal ray	18.5	17.8
Anal fin base	16.4	16.1
First anal spine	8.1	8.5
Second anal spine	14.4	14.7
Third anal spine	11.7	11.6
Longest anal ray	21.8	20.8
Caudal fin length	broken	broken
Caudal concavity	—	—
Pectoral fin length	32.7	32.5
Pelvic spine length	13.2	13.1
Pelvic fin length	23.4	23.5









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## The Genus *Platypilumnus* Alcock and Description of *P. jamiesoni* n.sp. from New Caledonia (Crustacea, Decapoda, Brachyura)

B. RICHER DE FORGES

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**ABSTRACT.** A new species of the genus *Platypilumnus*, *P. jamiesoni* n.sp., is described and illustrated from the upper bathyal zone of New Caledonia. A key to the four species in the genus is given along with new illustrations for *P. inermis*, *P. gracilipes* and *P. soelae*. The placement of this genus in Goneplacidae and its affinities with *Neopilumnoplax* Serène, 1969 are discussed.

**RÉSUMÉ.** Une nouvelle espèce du genre *Platypilumnus*, *P. jamiesoni* n.sp., est décrite et illustré de la zone bathyale supérieure de Nouvelle-Calédonie. Une clef des quatre espèces du genre est donnée ainsi que de nouvelles illustrations pour *P. inermis*, *P. gracilipes* et *P. soelae*. La position de ce genre dans les Goneplacidae et ses affinités avec *Neopilumnoplax* Serène, 1969 sont discutées.

RICHER DE FORGES, B., 1996. The genus *Platypilumnus* Alcock and description of *P. jamiesoni* n.sp. from New Caledonia (Crustacea, Decapoda, Brachyura). Records of the Australian Museum 48(1): 1-6.

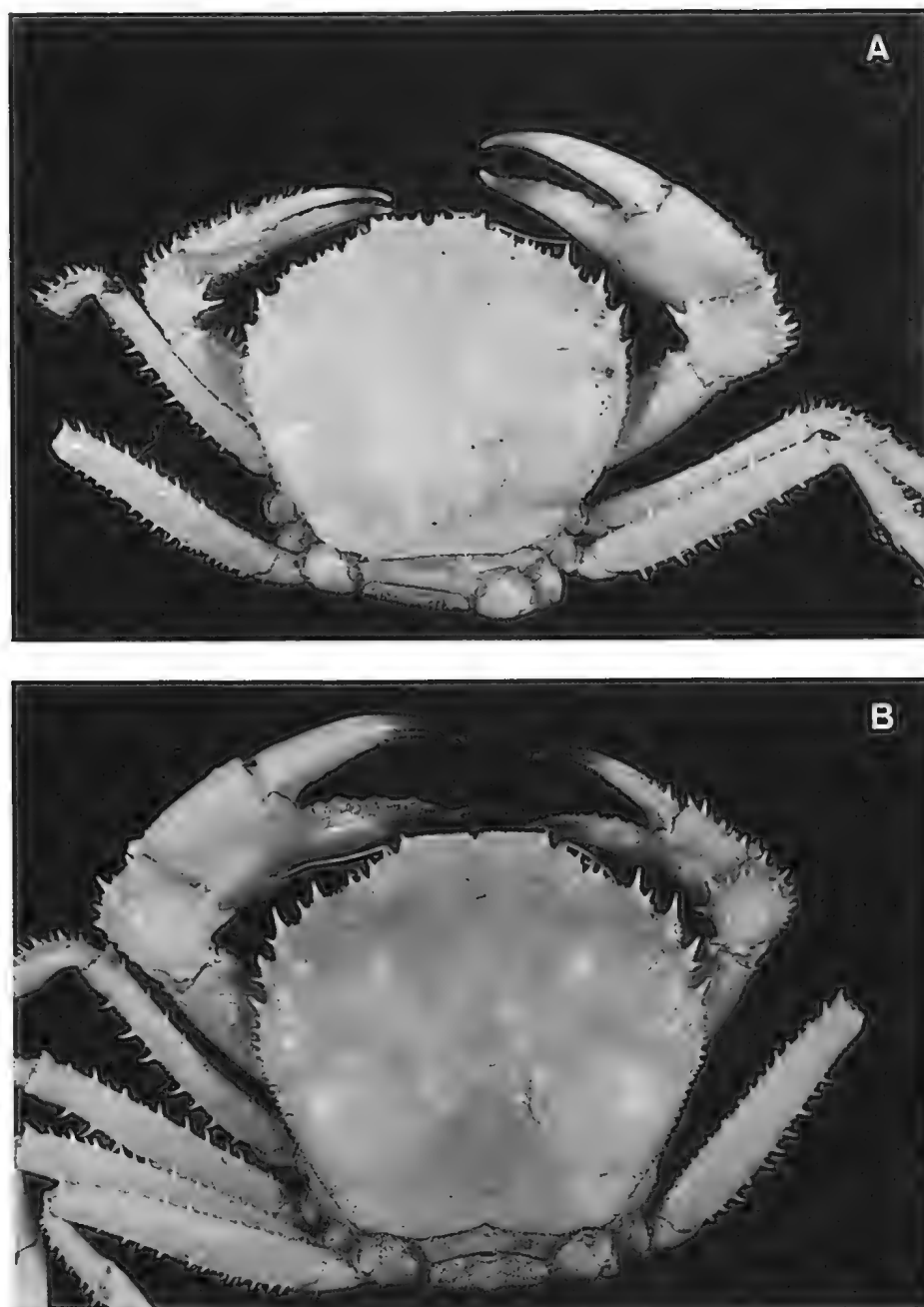
In the course of the BATHUS 2 expedition, on board R.V. *Alis*, we collected four specimens of the genus *Platypilumnus* Alcock, from the outer reef slope off New Caledonia. This resulted in an investigation of the three described species of the genus, known from a very small number of specimens, and led to the following description of a new species from New Caledonia, *Platypilumnus jamiesoni* n.sp.

The genus *Platypilumnus* has until now included the following species: *Platypilumnus gracilipes* Alcock, 1894, from the Andaman Sea and Vietnam; *P. inermis* Guinot, 1985, from La Réunion Island; and *P. soelae* Garth, 1987, from northwestern Australia.

Different authors have hesitated about the systematic position of this genus; it has been placed in both the Goneplacidae and the Geryonidae. According to Guinot (1969a), the genus *Platypilumnus* could be "étroitement apparenté à *Geryon*". Manning & Holthuis (1989) proposed that the Geryonidae should be limited to only the genera *Geryon*, *Chaceon* and *Zariquieyon* and that *Platypilumnus* be excluded. I consider *Platypilumnus* is closest to *Neopilumnoplax* and in consequence, I place *Platypilumnus* in Goneplacidae.

Abbreviations: CSIRO, Commonwealth Scientific and Industrial Research Organisation; MNHN, Muséum national d'Histoire naturelle; NTM: Northern Territory





**Fig. 1.** A, *Platypilumnus gracilipes*, female 23.6×27.5 mm, Vietnam, (MNHN B 6459). B, *P. inermis*, female ovigerous paratype 26.8×32 mm, Réunion Island (MNHN B 10525).

Museum; ORSTOM, L'Institut Français de Recherche Scientifique pour le Développement en Coopération.

### Systematics

*Platypilumnus gracilipes* Alcock, 1894

Fig. 1A

*Platypilumnus gracilipes* Alcock, 1894: 401, pl. 14, fig. 6.—Guinot, 1969b: 512, 692, fig. 4, pl. II, fig. 97.—Guinot, 1985: 16, 24, pl. II A–D.—Garth, 1987: 35.

**Material examined.** VIETNAM, 300 m, 22 December 1960, collected and identified by Zarenkov: 1 female 23.6×27.5 mm, with an Isopod Bopyrid parasite (MNHN B 6459).

**Remarks.** *Platypilumnus gracilipes* is very poorly known. It was described from the Andaman Sea and, since then, has only been found off Vietnam. Alcock (1894) described the fresh colouration as yellowish red.

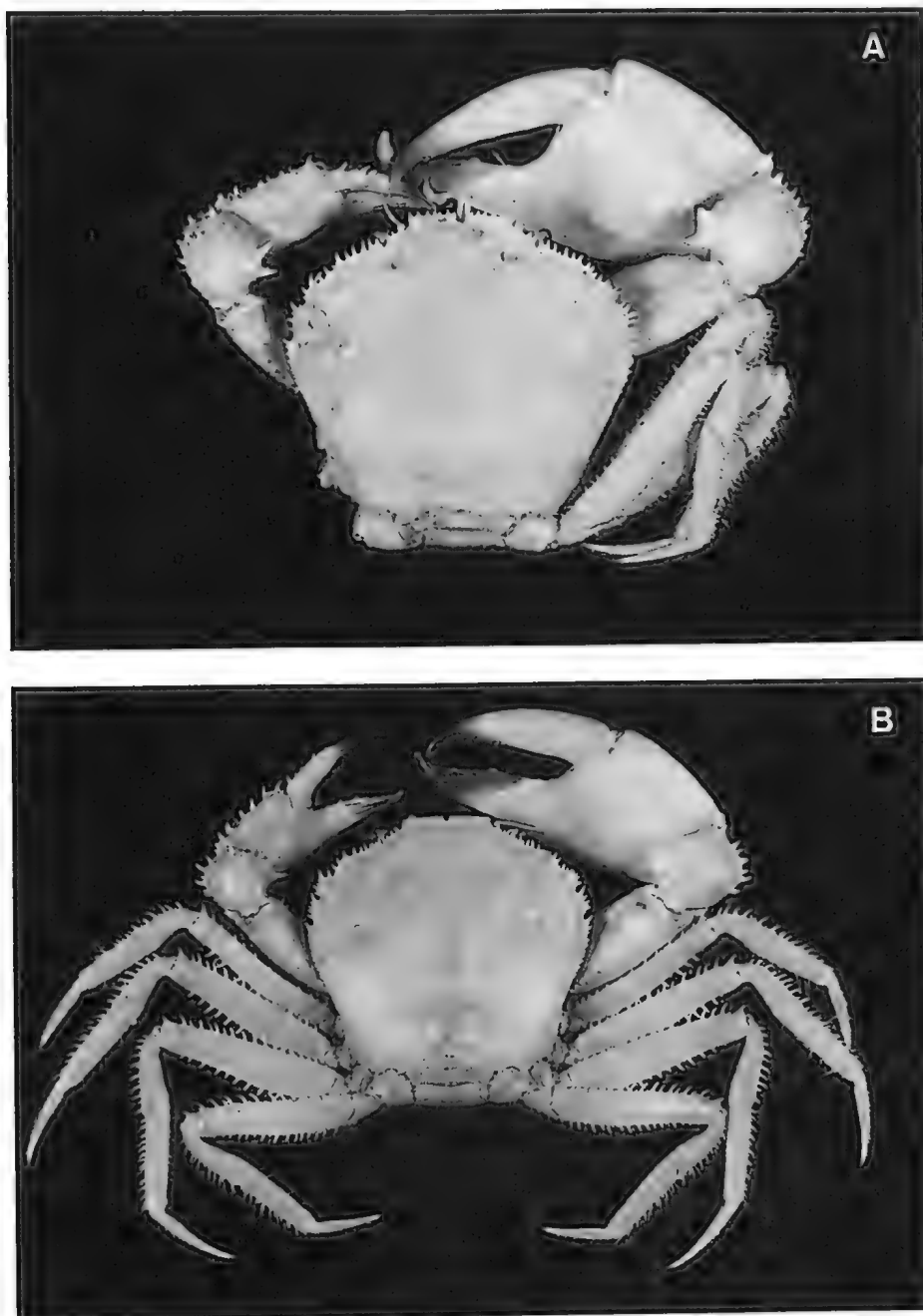


Fig. 2. A, *Platypilumnus soelae*, male paratype 32×40.2 mm, northwest Australia (NTM, number CR 002024). B, *P. jamiesoni* n.sp., male holotype 26.2×30.6 mm, New Caledonia, (MNHN B 22730).

*Platypilumnus inermis* Guinot, 1985

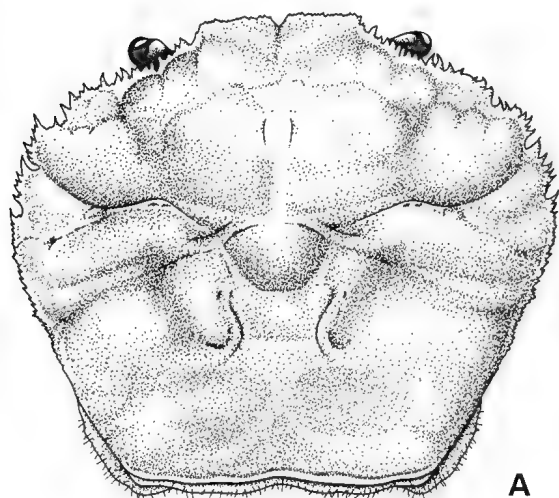
Fig. 1B

*Platypilumnus inermis* Guinot, 1985: 16, 24; fig. 2: B, D1, D2, E–H; fig. n.n.(A,B); pls II(E–J), IV.—Garth, 1987: 35.

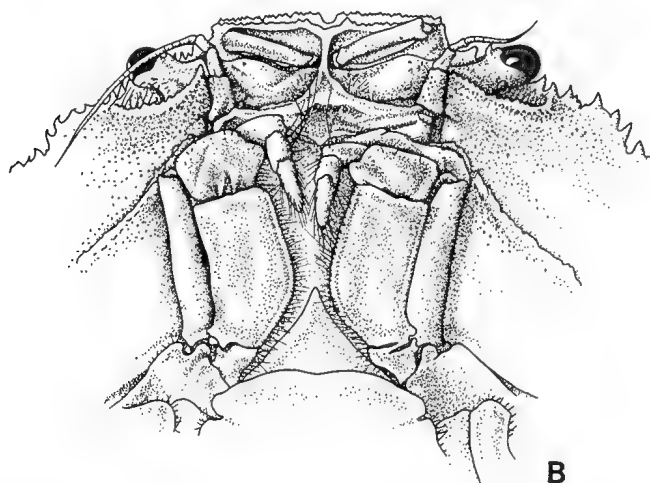
**Material examined.** LA RÉUNION, MD 32 cruise, station CP 60, 21°03.3'S 55°01.5'E, 460–490 m: 1 male HOLOTYPE 11×13 mm (MNHN B 10525), 1 ovigerous female PARATYPE 26.8×32 mm (MNHN B 10525).

**Remarks.** The male holotype of *P. inermis* is a juvenile and therefore may not be reliable to compare with other species. In spite of the small size of the specimen, heterochely is already well developed. It is the right claw that is more developed on the holotype, while on the female paratype, it is the left claw.

Guinot (1985: pl. IV) gives a colour photograph of the holotype of *P. inermis*: the carapace is orange over the anterior part, and mostly whitish on the branchial regions. Pereopods 2–4 have a white merus with the distal extremity orange, the carpus, propodus and dactylus are uniformly orange.



A



B

Fig. 3. *Platypilumnus jamiesoni* n.sp., holotype. A, dorsal view; B, anterior part of the ventral view.

*Platypilumnus soelae* Garth, 1987

Fig. 2A

*Platypilumnus soelae* Garth, 1987: 35, figs 1, 2A–E.

**Material examined.** AUSTRALIA, North West Shelf, station 64, FRV *Soela*, CSIRO cruise 0184, 14°49.4'S 121°32.3'E, 178 m, 12 February 1984: 1 male PARATYPE 32×40.2 mm (NTM, CR 002024). INDONESIA, *Karubar* cruise, station CP 59, 8°20.01'S 132°09.32'E, 405–399 m, 31 October 1991: 1 female 27.3×31.2 mm (PROLIPI).

**Remarks.** This species found recently on the continental shelf of Northwestern Australia, was known from only three male specimens. I attribute to it here

a female specimen from the Timor Sea, Indonesia. This female specimen shows the following characteristics: *chelipeds*, the right is bigger than the other (heterochely) with the external face of the propodus smooth; the propodus of the small cheliped is completely spinulose. *Female abdomen* seven segmented.

*Platypilumnus jamiesoni* n.sp.

Fig. 2B, 3A,B, 4A–C

**Material examined.** NEW CALEDONIA, BATHUS 2 cruise, station CP 741, 22°35.53'S 166°26.56'E, 700–950 m: 1 male HOLOTYPE, 26.2×30.6 mm (MNHN B 22730). Station CP 762, 22°18.86'S 166°09.78'E, 620–700 m, 16 May 1993: 1 male PARATYPE 18.6×21.5 mm, 1 female PARATYPE 20.4×25.2 mm (MNHN B 22731). Station CP 764, 22°09.41'S 166°02.93'E, 560–570 m, 17 May 1993: 1 male PARATYPE 30.4×35.4 mm; gonads sampled for sperm studies; MNHN B 22729.

**Description.** Size small. Carapace very flattened, regions visible but little marked. Surface of carapace smooth, carrying gastric groove with gastric fossetts. Curved groove on either side of the cardiac region. Front prominent and rectilinear, bimarginate, with median concavity; superior border finely serrated. Ten or eleven denticles, of equal length, on each side of median concavity. Epistome straight, with granular anterior border (Fig. 3B). Superior border of endostome forming crest interrupted on each side by concavity. Short, oblique crest on endostome.

Antenna short well protected, only flagellum passing anterior border of carapace. Anterolateral border curved, bearing some teeth flanked by spinules; spinules small, numerous, sharp.

Posterolateral border straight with row of granules anteriorly. Sub-hepatic region inflated and finely granular. Eyes short, little visible dorsally, hooked spine on ocular peduncle. Infra-orbital border with row of small spines ending in strong tooth at inner angle. Chelipeds of different sizes (also for females and juveniles): right cheliped very large on adult male, as long as carapace length; propodus very enlarged and flattened, with carina on inferior border; fingers apically hooked with black of fixed finger extending onto distal part; carpus quadrangular with two strong teeth at internal angle and row of seven spines on external border, superior face being smooth; superior border of merus carries some proximal spines. Small cheliped spinulate, less inflated; external face and superior border of propodus bearing strong spines, fingers thin and grooved; carpus spinular on superior face with two stronger spines at internal angle; merus with some distal spines on superior border and line of strong spines on ventral face; 2–3 spines on ventral face of coxa of pereopod 1. Pereopods 2–5 long and slender: merus with row of spinules on superior border and two parallel rows on inferior border; carpus and propodus with spinules only on superior border. Pleopods: as shown in Fig. 4. Colour: In life

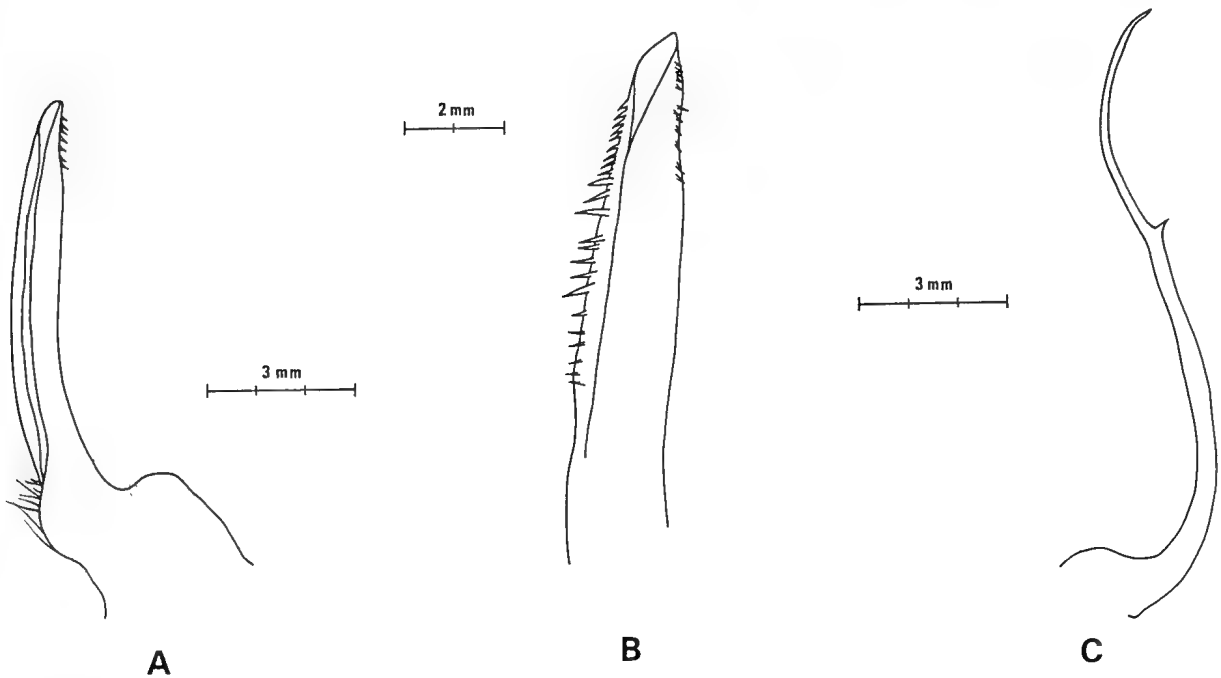


Fig. 4. *Platypilumnus jamiesoni* n.sp. male paratype 30.4×35.4 mm. A and B, first gonopod. C, second gonopod.

carapace is entirely milky white, pereopods 2–4 are reddish-orange on carpus, propodus and dactylus.

**Etymology:** dedicated to Professor Barrie Jamieson in honour of his work on the phylogeny of Brachyurans using the ultrastructural morphology of sperm.

**Remarks.** By the finely denticulate front, *P. jamiesoni* resembles *P. inermis*, however *P. inermis* has a much stronger spine at the outer edges of each side of frontal lobe, and the denticulation is much stronger. On *P. jamiesoni*, the infra-orbital border is denticulated, whereas it is only granular on *P. inermis*. The anterolateral border of the carapace carries numerous small, evenly sized spines on *P. jamiesoni* n.sp., whereas on *P. inermis* these

spines are fewer, stronger, and irregularly sized. The posterolateral border is practically smooth on *P. jamiesoni* n.sp., but has a line of granules and spinules on *P. inermis*. The meri of pereopods 2–5 are more slender and less spinulose on *P. inermis* than on *P. jamiesoni*.

*Platypilumnus jamiesoni* n.sp. differs from *P. soelae* by: the front being more finely spinular; the carpus of the large claw has only four spines on the external crest, whereas it is spinular and granular on the superior face of *P. soelae*; the infra-orbital border has a row of serrated spines, while there are only some large spinules on *P. soelae*; the black colour of the fingers is more extensive on *P. jamiesoni* than on *P. soelae*.

*P. jamiesoni* n.sp. lives on muddy bottom, in the upper bathyal zone, between 300 and 700 m depth.

#### Key to the species of *Platypilumnus*

1. Frontal margins with a row of strong spines or spinules ..... 2
  - Front finely serrulated ..... 3
2. Front with 5 strong spines each side of median groove ..... *P. gracilipes*
  - Front with 7–8 spinules on each side ..... *P. soelae*
3. Posterolateral border of carapace carries spinules and granules; infra-orbital border granular ..... *P. inermis*
  - Posterolateral border of carapace smooth; infra-orbital border denticulated ..... *P. jamiesoni* n.sp.

### Discussion

In several aspects the genus *Platypilumnus* Alcock, 1894, looks like *Neopilumnoplax* Serène, 1969: straight front divided into two lobes; flattened shell; a short first male gonopod and the second one long slender and curved (typical of many Goneplacids).

The very spinulose and serrulated anterolateral border of the carapace is similar to species of *Intesius* Guinot & Richer de Forges, 1981, but the spinulation of the walking legs is different. All these characters indicate *Platypilumnus* belongs to the Goneplacidae.

I have fixed the gonads from one of the specimens of *P. jamiesoni* n.sp., and from a specimen of the Geryonidae *Chaceon bicolor* Manning & Holthuis, 1989, so as to permit a study of the ultrastructure of the spermatozoa, in the hope that this will help to clarify the systematic problems.

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Serène, R., 1969 in Guinot, 1969. Recherches préliminaires sur les groupements naturels chez les Crustacés Décapodes Brachyours. VII. Les Goneplacidae. Bulletin du Muséum national d'Histoire naturelle, Paris, 41(2): 688–724, figs 83–146, pls 3–5.

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***Crenoicus* Nicholls, 1944**  
**(Crustacea, Isopoda, Phreatoicidea):**  
**Systematics and Biology of a New Species**  
**from New South Wales**

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**ABSTRACT.** The phreatoicidean isopod genus *Crenoicus* is found in upland swamps and springs throughout New South Wales and Victoria. We provide a new diagnosis of *Crenoicus* and review its 4 species, including one new species. As a benchmark for phreatoicidean external morphology, this paper provides a detailed description and illustrations of the new species found on the Boyd Plateau west of Sydney. Variation in some morphological features is high, with populations from separated swamps nearby showing localised differentiation. Measurements of large samples from two sites indicate that this species may reproduce continuously throughout the year, but with a substantial decrease during the winter.

WILSON, GEORGE D.F. & E. LYNNE HO, 1996. *Crenoicus* Nicholls, 1944 (Crustacea, Isopoda, Phreatoicidea): systematics and biology of a new species from New South Wales. Records of the Australian Museum 48(1): 7-32.

*Crenoicus* Nicholls, 1944 is known from the highlands of New South Wales and Victoria (Fig. 1). In New South Wales, species are found in *Sphagnum* swamps (discussed herein), spring-fed seeps (pers. obs.) and cavernicolous ground waters (S. Eberhard, pers. comm.). In Victoria, specimens are also found at lower altitudes among root masses in small streams. Where these habitats are undisturbed, localised population densities may exceed several hundred per square meter. Because of its relative abundance and ease of collection in the highlands of New South Wales, a new species (*Crenoicus buntiae* n.sp.) was chosen for our initial studies of the suborder Phreatoicidea.

First reviewed by Nicholls (1943, 1944), more recent publications on the suborder Phreatoicidea have dealt with their distribution (Knott, 1986; Banarescu, 1990; Eberhard *et al.*, 1991), specific aspects of morphology (Martin, Wägele & Knott, 1990; Wilson, 1991), or treatments of their phylogenetic position in the Isopoda (Wägele, 1989; Brusca & Wilson, 1991). Williams (1980, 1981) provides general accounts of the Phreatoicidea in Australian fresh waters. More recently Poore, Knott and Lew Ton (in press) revise the taxonomic names of the suborder and diagnose the families, primarily based on Knott (1975). Our paper provides an inventory of phreatoicidean external anatomy and

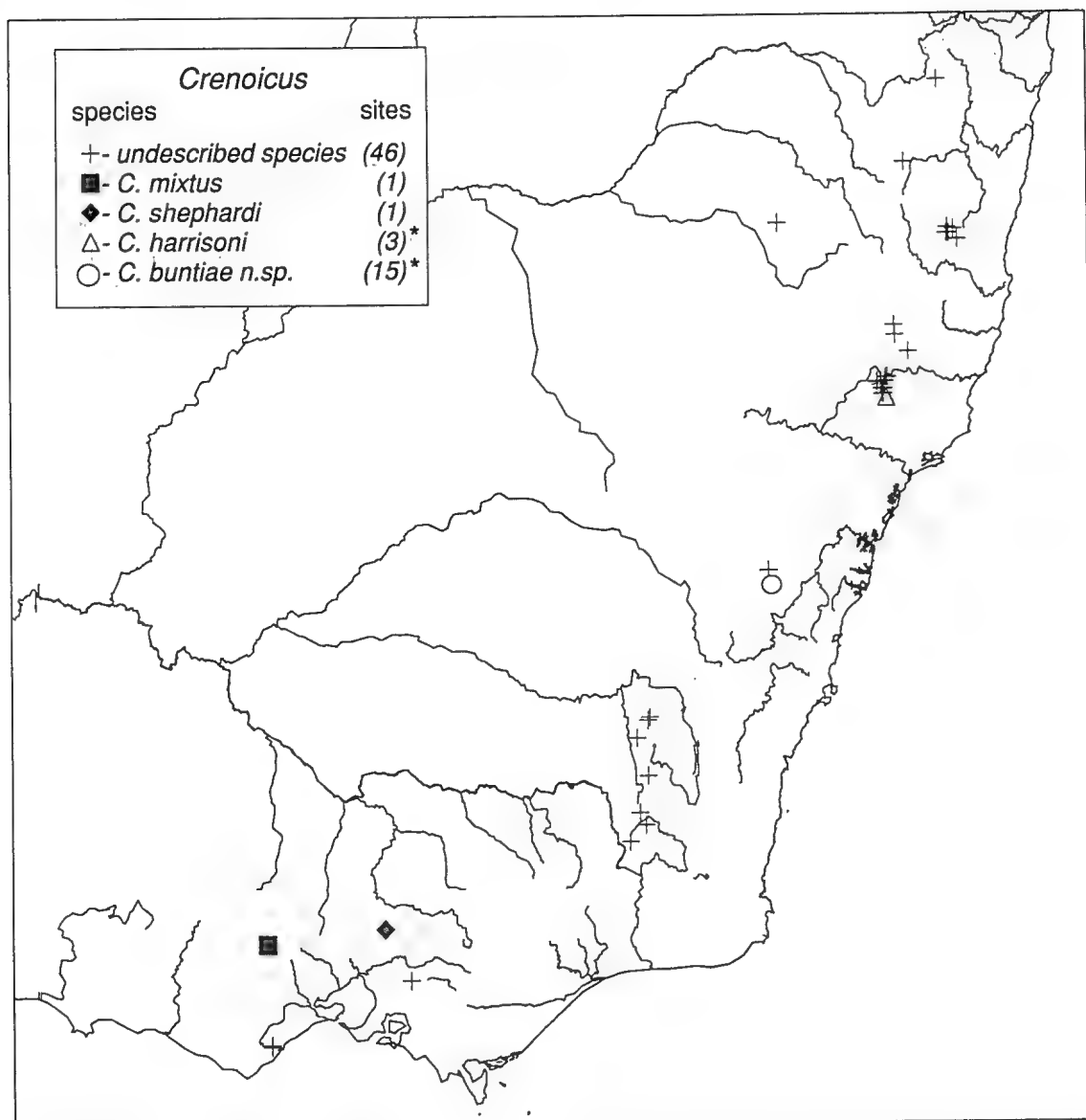


Fig. 1. Known distribution of species of *Crenoicus* in New South Wales and Victoria, Australia. Numbers within parentheses indicate the number of sites where specimens were found. Site numbers marked with an asterisk indicate overlapping sites, only one symbol shown in figure. Plus symbols may also overlap.

some information on variation in the species *Crenoicus buntiae* n.sp. The population biology of this species is also treated briefly. This work is part of a larger study of the Phreatoicoidea of Australasia.

### Methods

*Crenoicus* specimens were hand collected from moist seeps and from *Sphagnum* swamps. Positions were obtained using a portable GPS (Global Positioning System) instrument (radial accuracy 50–100 m). Specimens were found in localised concentrations amongst roots, stems and decaying vegetation, with all life stages occurring together. Once a clump of specimens was

found, larger handfuls of material were washed with water and elutriated into hand sieves, or vegetation was preserved for sorting in the laboratory. As a consequence, the samples reported here are not quantitative with respect to area sampled. The samples, however, are qualitative, i.e. they recovered approximate proportions of life stages in the populations. Because we tended to hand pick adults during collection, these larger stages are somewhat accentuated numerically in the data over the manca and juveniles. All specimens and associated material were fixed in approximately 10% formaldehyde solution buffered with sodium bicarbonate for at least one day, and then preserved in 70–80% ethanol.

Phreatoicoideans are difficult to measure in dorsal view because most specimens preserve in a flexed position.



Therefore, we introduce a new method for length measurements. Body lengths were measured in lateral view as a series of line segments along the body axis. Nodal points were chosen close to the transverse axes of segmental rotation to minimise the effects of flexure. A specimen was arranged so that the antennular basal articles and the tip of the pleotelson were in the same plane. The specimens were measured using dissecting microscope images captured by a CCD camera attached to a Macintosh. The images were measured using NIH-Image (author, W. Rasband). Moving from the tip of the pleotelson (or the head), line segment selections were made along the body axis roughly parallel to the dorsal surface, from segment boundary to segment boundary. In the pereon, the axis was positioned above the insertions of the pereopods. In the pleon, the axis was positioned on a line extending midway between the dorsal and the ventral surfaces of the last pereonite. On pleonite 5, this point is at a marked angle of the articulation. The endpoint on the head was located at the dorsal insertion of the antenna. Head length was measured from this position to the dorsal insertion of the head into the pereon. Pleotelson length was measured from the tip of the pleotelson to the articular angle in the posterior margin of pleonite 5. Variation in line positioning was minimised by taking the median of 3 replicate readings. When repeated measurements were consistent within 0.05 mm, only single measurements were taken. The data were transferred to a spreadsheet program for graphic presentation and analysis.

Head and pleotelson lengths were measured to check for bias in the measured body lengths. Linear regressions of these parameters against body length were significant ( $R^2 = 0.95$ ) at all sites indicating that preservation dependent changes in body length (particularly telescoping of the segments) did not greatly influence the results. Pleotelson length declined slowly relative to body length with increasing size suggesting that *C. buntiae* n.sp. did not grow in a completely linear fashion. This effect, however, was weak compared to the measurement variation. We do not report further on the head and pleotelson length data.

Populations, as defined in this study, are assumed to be contained within individual swamps, because the specimens of *Crenoicus* do not occur on the surrounding dry land or in the streams exiting the swamps. In studies of variation, mature specimens in each population were compared; maturity in males was assessed by the size of the first pereopod and the presence of penes with distal pores. A clear assessment of male maturity using the appendix masculina on the second pleopod requires the use of a compound microscope, so only the penes were used. In females, the presence of oostegites was used as a sign of maturity. Developmental stages were assessed independently from body size. Stages were identified as in previous studies (Forsman, 1944; Hessler, 1970; Wilson, 1981) as follows. Manca 1 individuals have no pereopod VII and pereonite 7 was much smaller than pereonite 6. Manca 2 individuals have a large pereonite 7 and pereopod VII was visible as a subcuticular analgen. Manca 3 individuals have a pereonite 7 nearly

same length as pereonite 6 and pereopod VII was expressed externally but rudimentary. Stage 4 individuals have a fully functional pereopod VII that was smaller than pereopod VI. Juveniles have a normal sized pereopod VII (larger than pereopod VI), but with no secondary sexual characters expressed (penes, oostegites). Juvenile males have rudimentary penes, defined as penes that have no distal opening and do not extend past the ventral margin of pereonite 7 posteriorly, on the coxae of pereopod VII. Adult males have fully developed penes (Figs 7C,D). Preparatory 1 females have small oostegal buds that do not extend more than halfway to the ventral midline. Preparatory 2 females have large oostegal buds, that extend to or nearly to the ventral midline. Brooding females have fully deployed oostegites, and may or may not have developing embryos. Although females rarely lost their brood during sample processing, embryonic stages were not assessed in this study.

Abbreviations: AM, Australian Museum; NMV, Museum of Victoria; USNM, United States National Museum of Natural History; ZMUC, Zoological Museum of the University of Copenhagen; bl, body length. Accession numbers beginning with "P" are from the Australian Museum Crustacea collection. In "Materials Examined" sections, samples collected on Australian Museum field trips are listed as "NSW nnn" where nnn is a sequential number, e.g., "NSW 485", one of two samples from Mumbadah Swamps designated as type material of *Crenoicus buntiae* n.sp. The style used for taxonomic descriptions of isopods is that of Wilson (1989).

## Taxonomy

### *Crenoicus* Nicholls, 1944

*Crenoicus* Nicholls, 1944: 21–23.

**Type species.** *Crenoicus mixtus* Nicholls, 1944.

**Generic diagnosis.** Eyes absent. Head length subequal to width in dorsal view, maxillipeds inserting near posterior margin of head. Dorsal surface with scattered fine setae, lacking tubercles or ridges. Pereonites lacking epimeral plates, all coxae visible in lateral view. Pereopodal coxae lacking distinct lateral projections. Gut with minimal typhlosome, "u" shaped in cross section. Pleonites with well-developed ventral epimera, pleopodal protopods not visible in lateral view. Pleotelson depth greater than length; posteriorly trilobed in dorsal or ventral view; medial tip not cleft, not distinctly longer than lateral lobes; ventral margin anterior to insertion of uropods with row of simple robust setae. Antennula terminal article shorter and narrower than subterminal articles, roughly globular. Right mandible lacking lacinia mobilis. Maxillula medial lobe narrower than lateral lobe, with 4 large plumose setae and 2 small simple setae (6 plumose setae sometimes occurring). Pereopod I male propodal palm with short, broadly conical, dorsally angled setae on low ridge; female propodal palm with row of broad based simple setae. Male pereopod

IV subchelate between dactylus and propodus, propodal palm with proximal large broad based setae. Penes smooth, lacking setae, strongly curved posteriorly, tapering distally to rounded point. Pleopod I exopod distally pointed, widest at midlength; endopod without setae. Male pleopod II appendix masculina curved, distally stylet-like, distal tip spatulate or spine-like with long single subdistal seta. Uropodal protopod distoventral margin with 1 robust distally spinose seta; propodal medial margin lacking distal projection; rami distally pointed, spine-like.

**Remarks.** Nicholls (1944) classified his genus *Crenoicus*, an exclusively Australian genus, in the subfamily Phreatoicinae which otherwise contains New Zealand forms. His subfamily concept may be too broad because the elongate subterranean genera *Phreatoicus* Chilton, 1883 and *Neophreatoicus* Nicholls, 1944 can be distinguished from the more typically shaped species of *Crenoicus* and *Notamphisopus* Nicholls, 1944. Nevertheless, Poore *et al.* (in press) expand the definition of the subfamily to include genera of Paraphreatoicinae Nicholls, 1944 plus *Uramphisopus* Nicholls, 1943, and raise this group to family level. We do not diagnose the family Phreatoicidae because the family level systematics of the Phreatoicidea should be revised using phylogenetic methods.

With this new composition of the Phreatoicidae, more genera must be compared with *Crenoicus*. The New Zealand species of *Phreatoicus* and *Neophreatoicus* are much more elongate than other Phreatoicidae and have a pleotelson whose length is greater than its depth. *Crenoicus* can be distinguished from *Colacanthotelson* Nicholls, 1944, *Mesacanthotelson* Nicholls, 1944 and *Onchotelson* Nicholls, 1944 by the lack of any unusual alterations of the dorsal cuticle, the pleotelson tip or the coxae (i.e. the cuticle is not rugose, the pleotelson does not have an elongate tip and the coxae are not laterally expanded). The other phreatoicid genera *Uramphisopus* Nicholls, 1943, *Colubotelson* Nicholls, 1944, *Metaphreatoicus* Nicholls, 1944, *Paraphreatoicus* Nicholls, 1944 and *Notamphisopus* Nicholls, 1944 are more similar to *Crenoicus*. Unlike Knott (1975) and Poore *et al.* (in press), we are uncertain whether the genera *Metaphreatoicus*, *Colubotelson* and *Paraphreatoicus* should be synonymised into *Uramphisopus*. *Uramphisopus pearsoni* Nicholls, 1943 has a large medial extension of the uropodal protopod, while none of the species attributed to other three genera have this feature. Other characters, such as the setation of the pleopodal endopods and the uropods, also suggest more diversity than a single genus should contain. Consequently, we prefer to recognise these genera until the suborder is revised. All of these genera, however, lack a distally pointed appendix masculina seen in *Crenoicus* and instead have a typically rounded tip with multiple setae. These genera also differ in other details such as the setation of the first pleopod and the number of spinose setae on the distal margin of the uropodal protopod. While most Australian Phreatoicidae have

eyes, *Crenoicus* species are completely blind, although the head may have a cuticular remnant of the eyes. *Crenoicus* species also have a subcuticular white patch of unknown function in the ocular region of the head.

**Species included.** *Crenoicus mixtus* Nicholls, 1944; *C. shephardi* (Sayce, 1900); *C. harrisoni* Nicholls, 1944 and *C. buntiae* n.sp. Nicholls (1944: 31) noted another undescribed species from the New England region of New South Wales. The morphological conservatism of this genus coupled with substantial intrapopulation variation in some characters (discussed later in this paper) makes identification of species difficult. A complete species inventory for *Crenoicus*, therefore, will require careful morphometric and genetic studies.

**Distribution of *Crenoicus* species.** Throughout springs and swamps of Victoria and New South Wales: near Ballarat (*C. mixtus*), Plenty Range near Melbourne Vic. (*C. shephardi*), Barrington Tops NSW (*C. harrisoni*), Boyd Plateau NSW (*C. buntiae* n.sp.), Otway Range Vic. (*Crenoicus* sp.—undescribed). Our collecting activities have shown other undescribed species of *Crenoicus* to be widespread in NSW springs and marshes above 1000 m (see Fig. 1).

#### *Crenoicus mixtus* Nicholls, 1944

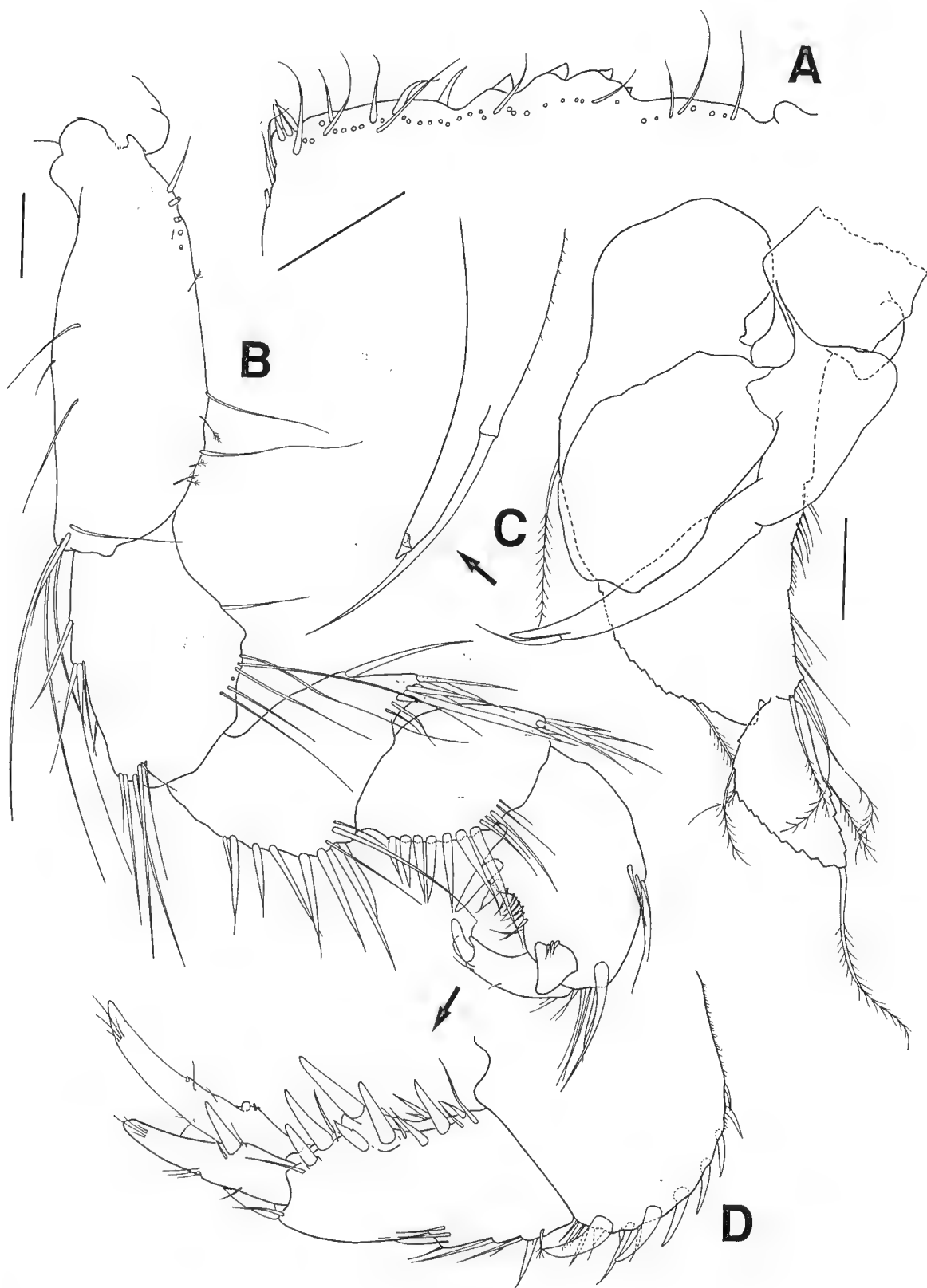
*Crenoicus mixtus* Nicholls, 1944: 23–27, figs 38–39.

**Syntypes.** Types not examined, apparently lost (Poore *et al.*, in press). Nicholls (1944) reported 1 male bl (body length) 14 mm, 6 females and 23 other specimens that he used for his description.

**Type locality.** “On Dividing Range near Ballarat [Victoria], in springs and soaks at the source of that city’s water supply” (Nicholls, 1944: 27). Assuming that Winter Swamp near Ballarat is the type locality, this locality might be 37°33'S 143°48'E.

#### **Diagnosis (derived from Nicholls, 1944: figs 38–39).**

Posterior robust seta on ventral margin of pleotelson subequal or shorter than more anterior robust seta. Maxillipedal epipod distally rounded. Male pereopod I basis anteroproximal surface with less than 5 setae, lacking dense group of setae. Male pereopod IV propodus not dorsally expanded, distal width less than palm length, anterior surface with distal indentation; ischium posterodistal margin with approximately 10 long setae. Pleopod I exopod proximally concave, widest point approximately midlength. Pleopod II appendix masculina with smooth tapering shaft, distal tip pointed (detail unknown, possibly with seta vis. Nicholls, 1944: fig. 39, 13.2); endopod distally rounded, lacking indentation; distal segment of exopod longer than wide, lateral margin proximally straight sided.



**Fig. 2.** *Crenoiculus shephardi* Sayce, 1900. Limbs. NMV J213, holotype male, bl (body length) 11.3 mm. A, pereopod I, palm. B, pereopod IV. C, male pleopod II with distal enlargement of endopodal stylet. D, detached right pleuron of pleotelson with uropod in lateral view. Scale bar 0.2 mm.

**Remarks.** This diagnosis remains preliminary because we did not examine the types, which have been lost, depending only on Nicholls' description and illustrations. Some character states in the diagnosis depend on the accuracy of Nicholls' drawings. In most cases, we have found his rendition of shapes to be accurate, but setal details may be more fallible. Although Nicholls writes that "... penial stylet, unarmed terminally..." (Nicholls, 1944: 27), he illustrates it with a small distal split, suggesting that the stylet may have a seta as in other *Crenoicus* species. In any case, a pointed tip of the appendix masculina is a putative synapomorphy of the genus.

*Crenoicus shephardi* (Sayce, 1900)

Fig. 2

*Phreatoicus shephardi* Sayce, 1900: 25, pl. 3.  
*Phreatoicus shephardi*. Sheppard, 1927: 112.  
*Crenoicus shephardi*. Nicholls, 1944: 27–28.

**Material Examined.** HOLOTYPE male, NMV J213, bl 11.3 mm, collected 1899 by J. Shephard.

**Type Locality.** Source of a spring flowing into Wallaby Creek, Plenty Ranges, Victoria, approximately 37°24'S, 145°15'E.

**Diagnosis.** Posterior robust seta on ventral margin of pleotelson longer or subequal to more anterior robust seta. Maxillipedal epipod obtusely pointed distally. Male pereopod I basis anteroproximal surface with 5 or less setae, lacking dense group of setae. Male pereopod IV propodus not dorsally expanded, distal width less than palm length, anterior surface with distal indentation; ischium posterodistal margin with 4 long setae. Pleopod II appendix masculina with smooth shaft; distal tip laterally spatulate, medially thickened with no tiny denticles, distal seta basally narrower than distal tip; endopod with distal indentation; distal segment of exopod longer than wide, lateral margin proximally rounded.

**Remarks.** Only a single male specimen from the Museum of Victoria (NMV J213; Fig. 2) is known, from which the above diagnosis was derived. *Crenoicus shephardi* is largely similar to the other species of the genus, but the obtusely pointed maxillipedal epipod and the indented endopod of second pleopod should be sufficient to identify this species. The mouthparts are missing from the holotype, so the features of the mouthparts are obtained from Sayce's (1900) original description and figures. The details in our diagnosis should be checked against new material if available.

*Crenoicus harrisoni* Nicholls, 1944

Figs 3, 4

*Crenoicus harrisoni* Nicholls, 1944: 28–31, fig. 40.  
*Phreatoicus shephardi*. Chilton, 1917: 91, fig. 13–17.

**Material examined.** P44459, adult male, bl 13.1 mm (Fig. 3, 4F–H) designated as NEOTYPE. P4076, 12 specimens; P4081, 1 specimen, 5 slides (prepared by C. Chilton); P4082, 1 specimen, 5 slides (prepared by C. Chilton). Other specimens not examined from AM P4076: NMV J13924, 6 specimens; specimens sent to G.E. Nicholls: 4 sent during 1926, 2 during 1928.

**Neotype locality.** Barrington Tops "near Dungog" (Chilton, 1917: 82) New South Wales, Australia, in roots and stems of moss in large swamp on plateau, 32°S, 151°27'E (position approximate), altitude 1400 m, collected by C. Hedley, December 1915.

**Remarks on neotype designation.** As with many of Nicholls' species, the types of *C. harrisoni* cannot be found. The collections of the Australian Museum contain specimens that were collected by C. Hedley during December 1915 (P44459, P4076, P4081, P4082). Poore *et al.* (in press) list these specimens as the syntypes of *C. harrisoni*. Nicholls (1944), however, based his descriptions on specimens given to him by Professor L. Harrison. He states in his text (Nicholls 1944: 31): "Occurrence. Collected by the late Professor Harrison at Mount Royal (Barrington Tops); presumably identical with that collected nearby some years earlier (Jan., 1916) by C. Hedley." [italics added]. The specimens reported from the vicinity of Mount Royal were probably obtained during 1925 when Harrison was actively collecting in the region (data from AM Crustacea collection database). The AM register entry of P4076—from which the neotype, P44459, comes—notes that Nicholls was sent 6 Hedley specimens, so that he may have compared the Hedley and the Harrison material, although his text suggests that he did not. The Harrison specimens are lost, along with many other phreatoicidean types that were held in Nicholls' collection at University of Western Australia (Jones, 1986; Poore *et al.*, in press). No populations of *Crenoicus* were found during a recent (January 1995) inspection of aquatic habitats around Mount Royal. The only active spring in this area was in a badly disturbed cattle handling area (altitude approximately 800 m, west of Mount Royal) that lacked *Sphagnum* moss. Moreover, the narrow ridge topography of Mount Royal is unlike other typical *Crenoicus* habitats in New South Wales, such as on the nearby Barrington Tops where known populations of *C. harrisoni* exist. Nicholls must have meant the Mount Royal Range, in which Barrington Tops is included. Therefore, we have selected a male neotype (P44459) from the Hedley collection from Barrington Tops which was described by Chilton (1917) as *Phreatoicus shephardi* Sayce. The chosen specimen is not a lectotype because Nicholls may

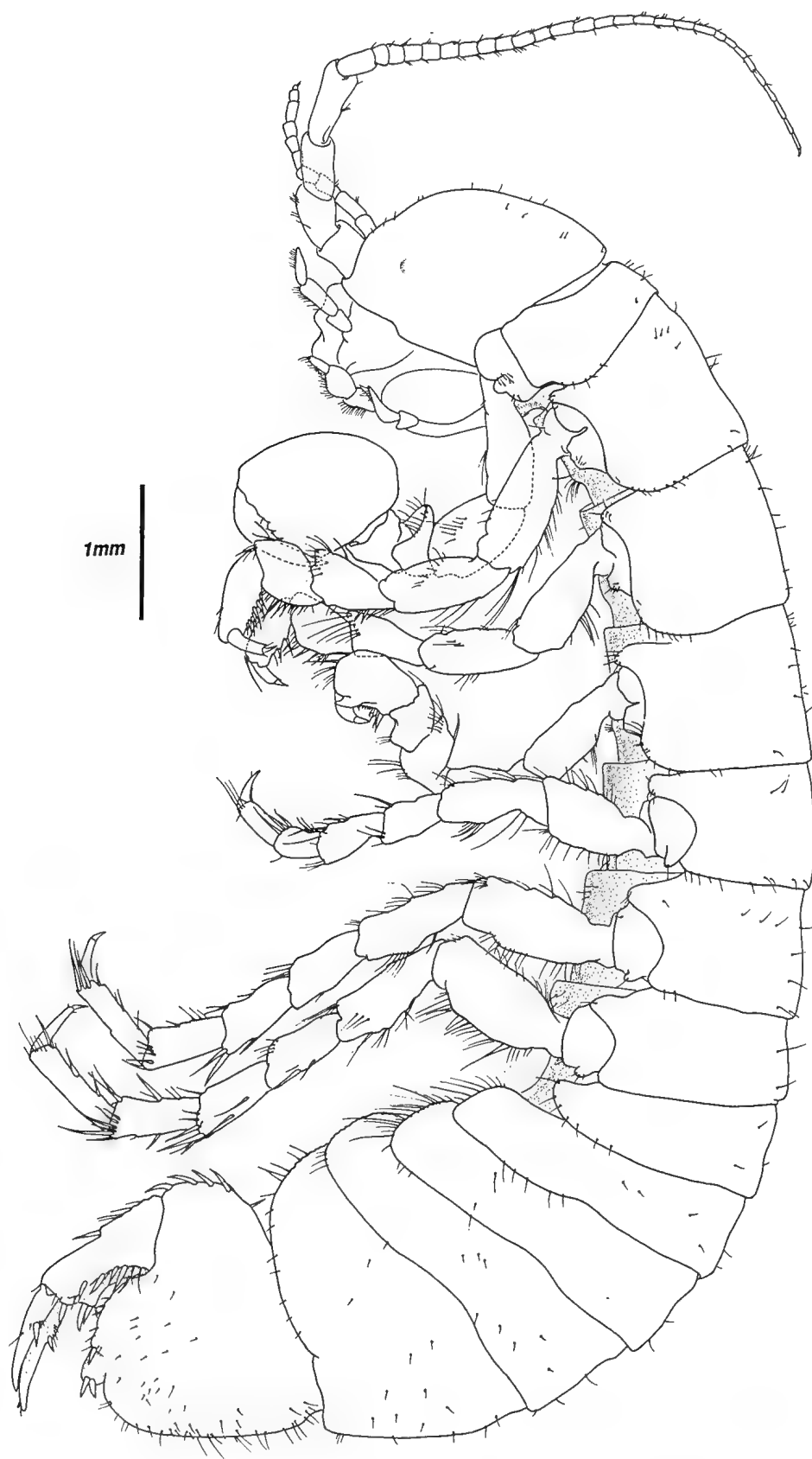


Fig. 3. *Crenoicus harrisoni* Nicholls, 1944. Body, lateral view. AM P44459, adult male neotype, bl 12.7 mm. Scale bar 1 mm.

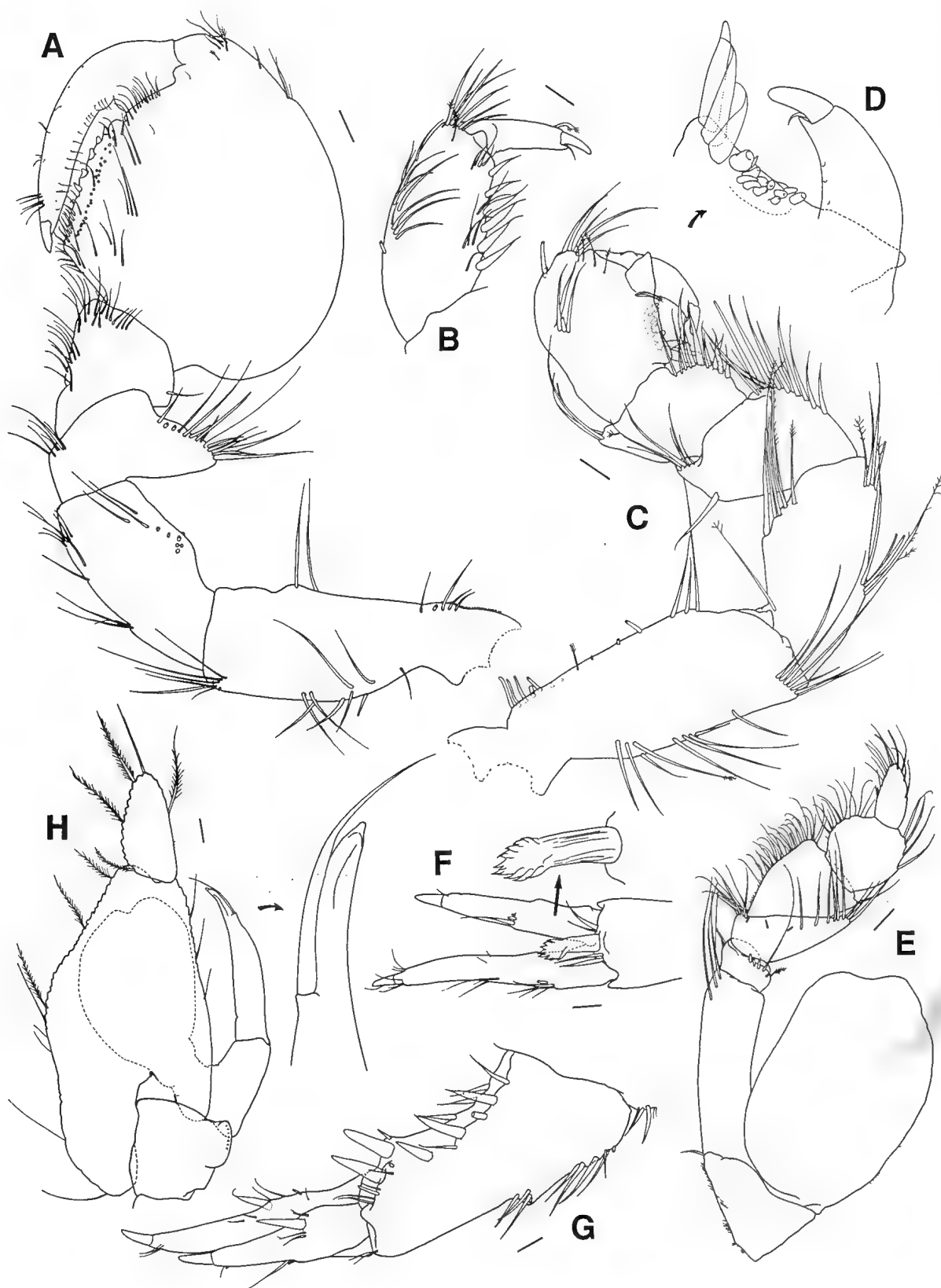


Fig. 4. *Crenoicus harrisoni* Nicholls, 1944. Limbs. A–E, AM P4076, adult male, bl 12.7 mm. G, H: AM P44459, adult male neotype, bl 13.1 mm. A, left pereopod I; B, right pereopod II, dactylus and propodus; C, D: right pereopod IV; C, whole limb lateral view; D, palm, medial view. Scale bar 0.1 mm.

not have used the Hedley collection for his description. Nevertheless, Hedley specimens have nomenclatural value because they agree in detail with Nicholls' illustrations (apparently he looked at them without changing their identification), and the specimens are from Barrington Tops, Nicholls' apparent type locality for the species. Of the material available at this time, only the Hedley specimens match Nicholls' description for *Crenoicus harrisoni*.

**Diagnosis.** Posterior robust seta on ventral margin of pleotelson subequal or shorter than more anterior robust seta. Maxillipedal epipod with concavity on distal margin. Male pereopod I basis anteroproximal surface with less than 5 setae, lacking dense group of setae. Male pereopod IV propodus dorsally expanded, distal width greater than palm length; ischium posterodistal margin with approximately 3–4 setae. Pleopod I exopod proximal part linear (not concave), widest point approximately midlength. Pleopod II appendix masculina with smooth shaft; distal tip laterally spatulate, medially thickened with 2–3 tiny rounded denticles, distal seta basally narrower than distal tip; endopod with distal indentation; distal segment of exopod longer than wide, lateral margin proximally rounded.

**Remarks.** This diagnosis will distinguish *Crenoicus buntiae* n.sp. from *C. harrisoni* Nicholls, as well as other undescribed species we have observed from New South Wales and Victoria. These two species, while being largely similar, are most easily separated using the shape of the male pereopod IV propodus, being dorsally expanded in *C. harrisoni* and evenly rounded in *C. buntiae* n.sp. Nicholls (1944: 29) remarked that the propodus lacked evident palm or "spines", differing from Chilton's (1917) account of the same species. We suspect that Nicholls missed the setae on the palm because they are strongly angled medially. Moreover, the propodus IV does have a small but well-developed palm, similar to other species. When making an identification of species of *Crenoicus*, one should be certain that a fully mature male is being used. Maturity in the male can be assessed by the size of the propodus of first pereopod.

### *Crenoicus buntiae* n.sp.

Fig. 5–15

**Type material.** HOLOTYPE. P44348, adult male, bl 10.76 mm; NSW 758, Mumbadah Swamps, Kanangra-Boyd National Park, NSW, Australia; *Sphagnum* swamp at head of Mumbadah Creek, Boyd Plateau: NSW 758, 33°53.73'S, 150°4.05'E, 1200 m, 2/4/1992, collected by G. Wilson and party. PARATYPES from NSW 758: P44349, adult male, body length 10.8 mm, dissected; P44350, preparatory female, bl 8.25 mm, intact; P44351, preparatory female, bl 8.5 mm; P44352, brooding female, bl 6.35 mm, partially dissected; P44353, preparatory 2 females, bl 7.7 mm, intact; P44354, brooding female, bl 6.7 mm, intact; P44355, adult male, bl 10.4 mm, intact;

P44356, adult male, cephalon only; P44394, preparatory female, bl 5.2 mm, partially dissected; P44359, adult male, bl 9.7 mm, partially dissected; P44395, adult male, bl 6.5 mm, partially dissected; P44396, brooding female, bl 6.2 mm, partially dissected; P44457, 303 specimens used for measurements. PARATYPES from NSW 485, 33°53.76'S, 150°3.92'E, 1200 m, 18/11/1992, collected by G. Wilson and party: P44463, 197 specimens used for measurements; NMV J40520 male, 2 females; USNM 253241, male, 2 females; ZMUC CRU1774, male, 2 females.

**Other material: Kanangra-Boyd National Park, NSW.** P44458, NSW 757: Luther's Creek near road, *Sphagnum* & sedge spring in old paddock, 33°52.78'S, 150°2.72'E, 1215 m, 2/4/1992. P44480, NSW 486: Luther's Creek near road, spring-fed swamp of *Sphagnum* and gelatinous algae in fresh water over silt, 33°52.82'S, 150°2.62'E, 1225 m, 19/11/1992. P44474, NSW 487: Roly Whalen Swamp, *Sphagnum* moss & mixed aquatic vegetation in fresh water 33°58.55'S, 150°3.30'E, 1180 m, 17/11/1992. P44475, NSW 478: Jensen's Swamp, *Sphagnum* moss & mixed aquatic vegetation in fresh water, 33°58.65'S, 150°2.76'E 1175 m, 17/11/1992. P44476, NSW 479: Jensen's Swamp, *Sphagnum* moss & mixed aquatic vegetation in fresh water, 33°58.59'S, 150°2.78'E 1175 m, 17/11/1992. P44460, NSW 480: Dingo Swamp, mixed sedge *Sphagnum* and sawgrass in fresh water, 33°59.34'S, 150°2.39'E 1180 m, 17/11/1992. P44477, NSW 482: Boyd Hill Swamp, downstream from clumps of *Sphagnum* & sedge in fresh water, 33°56.97'S, 150°1.44'E, 1225 m, 18/11/1992. P44478, NSW 483: "Oldmeadow Swamp," *Sphagnum* and mixed water plants in spring fed fresh water, 33°56.56'S, 150°2.48'E, 1211 m, 18/11/1992. P44479, NSW 484: Belarah Swamp, amongst *Sphagnum*, sticks & roots submerged in fresh water stream, 33°54.31'S, 150°4.65'E, 1185 m, 18/11/1992. All material collected by G. Wilson and party.

**Other material, Council Creek population (*Crenoicus* sp. cf. *buntiae*).** P44481, NSW 487: Swamp near road outside of Kanangra-Boyd National Park boundary, NSW, eastern headwaters of Council Creek, in *Sphagnum* & gelatinous algae over gravelly substrate, 33°50.51'S, 150°0.80'E, 1180 m, 19/11/1992, collected by G. Wilson and party.

**Etymology.** This species is named after Ms Bunty Oldmeadow, who accompanied us on a November 1992 field trip to collect isopods on the Boyd Plateau. Bunty aided our collecting effort and maintained a cheerful demeanour despite chilling rain and countless leeches. Ms Oldmeadow also suggested "friartuck" as a "common" name for phreatoicids.

**Diagnosis.** Posterior robust seta on ventral margin of pleotelson subequal or shorter than more anterior robust seta. Maxillipedal epipod distally rounded. Male pereopod I basis anteroproximal surface with less than 5 setae, lacking dense group of setae. Male pereopod IV propodus not dorsally expanded, distal width less than palm length; ischium posterodistal margin with approximately 3–4 setae. Pleopod I exopod proximal part straight (not concave), widest point approximately midlength. Male pleopod II appendix masculina with smooth shaft; distal tip laterally spatulate, medially thickened with 2–3 tiny



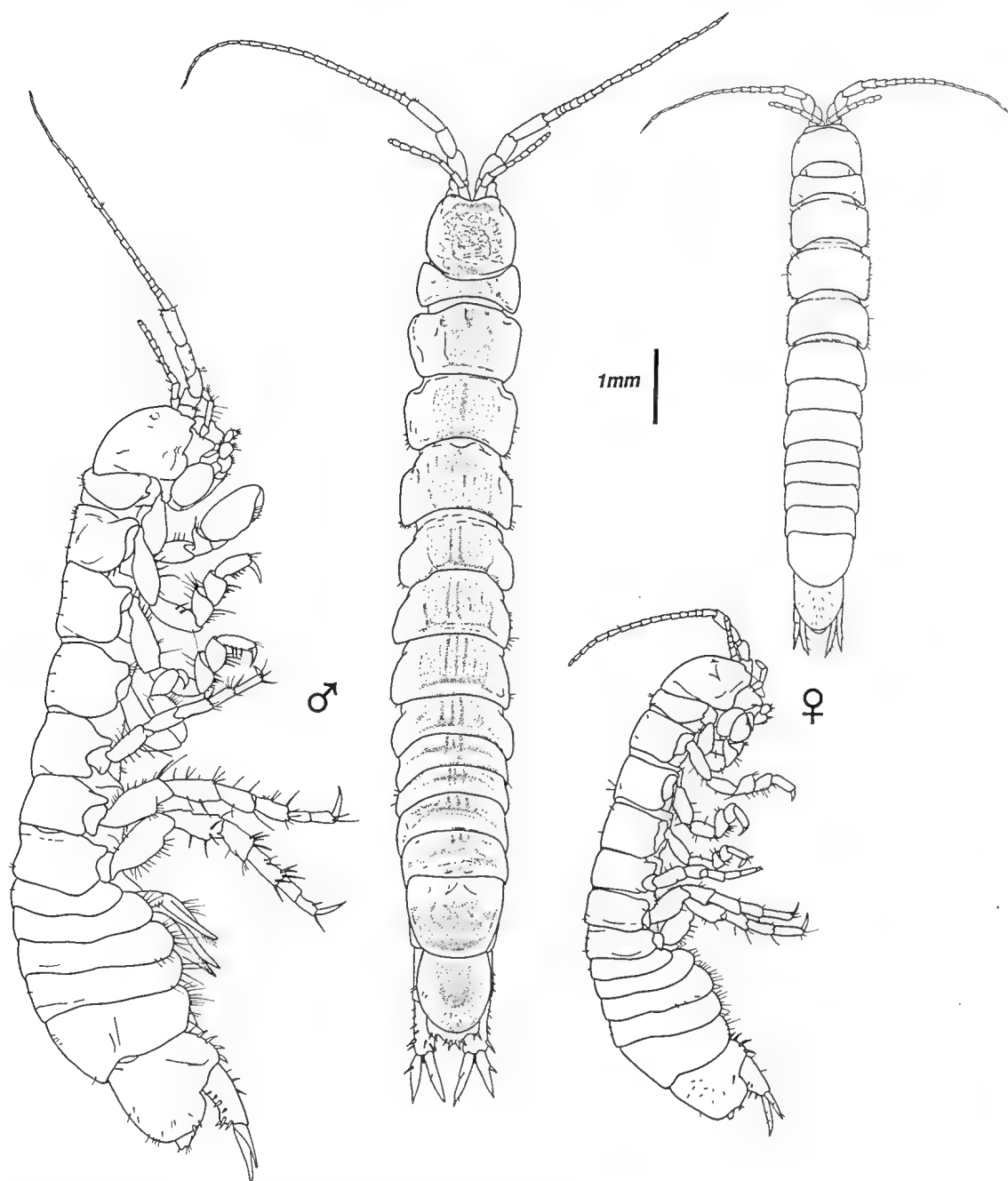
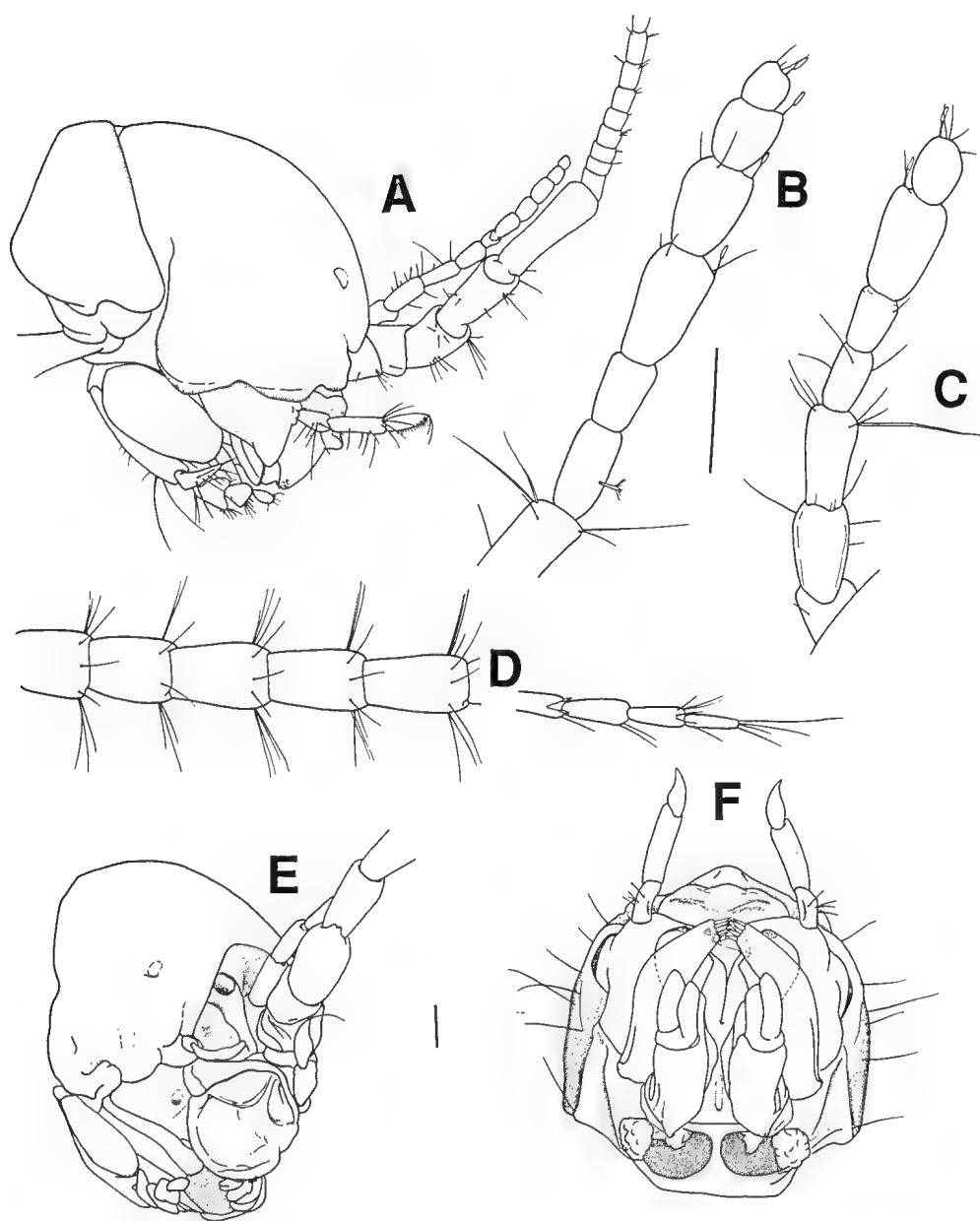


Fig. 5. *Crenoicus buntiae* n.sp. body, dorsal and lateral views. AM P44348, male holotype, bl 10.76 mm; P44350, preparatory female, bl 8.25 mm. Scale bar 1 mm.

rounded denticles, distal seta basally narrower than distal tip; endopod distal rounded, lacking indentation; distal segment of exopod longer than wide, lateral margin proximally rounded.

**Description.** *Head* (Fig. 5, 6A,E,F). Eye region roughly oval in shape, fully sessile, lacking pigment and ocelli, maximum diameter 0.09 head depth, orientation of longest axis vertical; living specimens with large dendritic subcuticular white patches in eye region. Cuticle of head

smooth, tubercles absent, with few long scattered setae. Head shape in dorsal view roughly subcircular, only slightly wider than long, width 0.9 pereonite 1 width. Head lateral profile forming smooth open curve. Cervical groove straight, weakly indented, extending variably above anterolateral margin of pereonite 1. Mandibular groove absent. Mandibular notch present. Clypeal notch present. Antennal notch present. Frontal process above antennule absent. Mouth field adjacent to posterior margin of head, maxillipeds inserting 0.08 head length



**Fig. 6.** *Crenoicus buntiae* n.sp. head, antennulae and antennae. A, E, F: P44349, adult male, bl 10.8 mm. B, D, P44348, holotype male, bl 10.76 mm. C, P44350, preparatory female, bl 8.25 mm. A, E–F, head: lateral, frontal oblique and ventral views, last with maxillipeds removed. B, C, male and female antennulae, proximal article truncated. D, antenna, flagellar segments, midlength and distally. Scale bar 0.2 mm.

from posterior margin of head.

**Pereon** (Fig. 5). Setation on dorsal surface sparse and scattered, seta thin and short. Dorsal surface of pereon smooth. Pereon only 10% wider than head. Pereonites much wider than long. Coxae on pereonites 2–7 with distinct sutures. Sternal processes absent. Gut with U-shaped typhlosole; hindgut caecae absent.

**Pleonites** (Figs 5, 7). Pleonites with large ventrolateral pleural plates extending well below level of pereonal coxae, basal region of pleopods not visible; pleonite 1

pleurae distinctly shorter than pleurae of pleonites 2–5. Pleonites 1–5 depth 1.2–1.3, 1.5–1.6, 1.7–1.8, 1.7–1.8, 1.3–1.4 pereonite 7 tergite depth, respectively. Pleonites 1–4 length subequal, less than half length of pleonite 5, width 0.68 total length in dorsal view.

**Pleotelson** (Fig. 7A–C,E). Lateral length 0.11–0.17 body length (mean = 0.14, N = 298), dorsal length 1.3 width (N = 2), lateral length 0.8–0.9 depth (N = 2), lateral median lobe length 0.1 pleotelson total length. Telsonic region distinct, trilobed, median lobe length 0.1

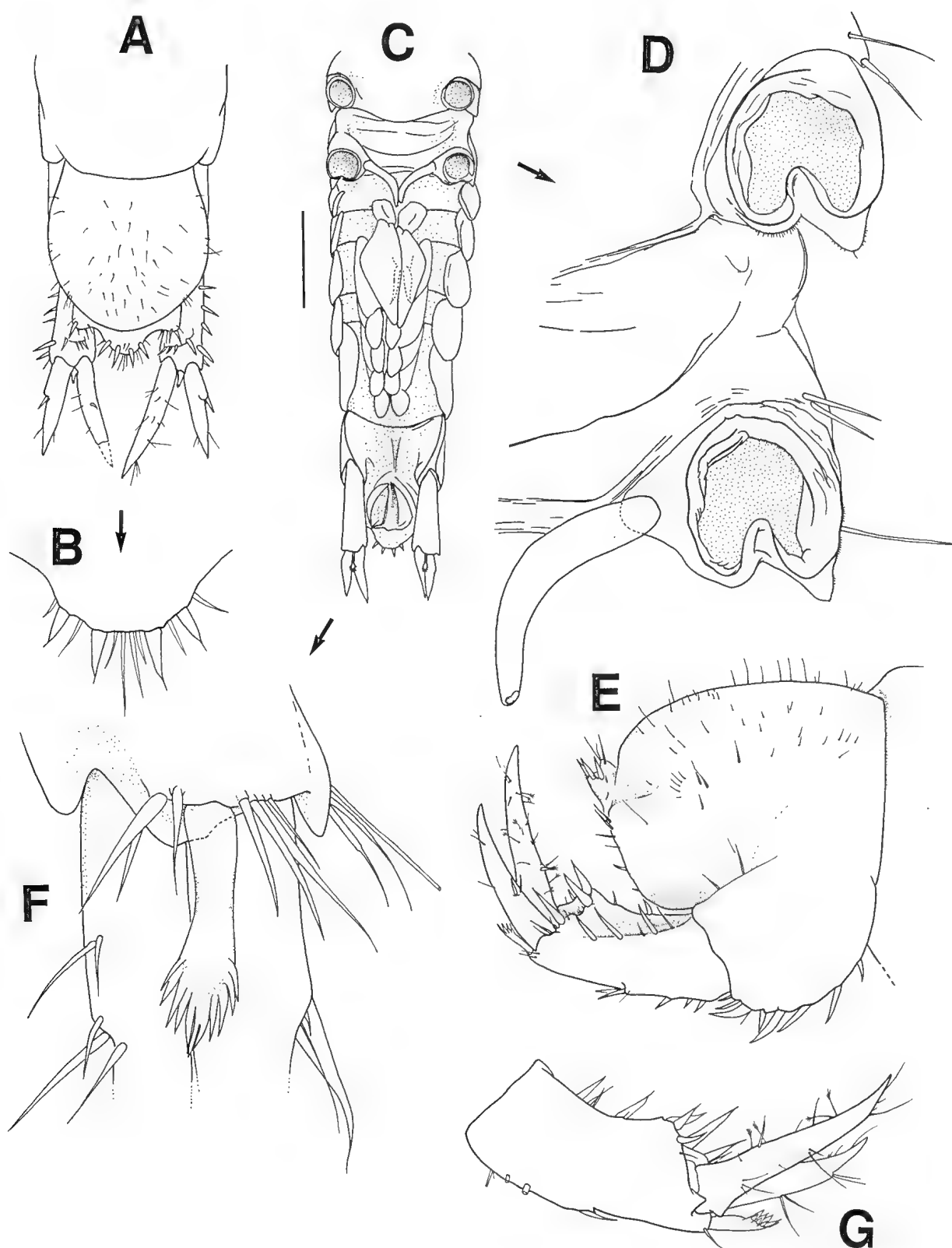


Fig. 7. *Crenoicis buntiae* n.sp. male pleon. AM P44349, adult male, bl 10.8 mm. A, pleotelson and uropods, dorsal view. B, pleotelson, median lobe. C, pereonites 6-7 and pleon, ventral view. D, coxae VI-VII, showing penes. E, pleotelson and right uropod, lateral view. F, right uropod, insertions of rami and robust distally spinose seta, ventral view. G, right uropod, medial view. Scale bar 1 mm.

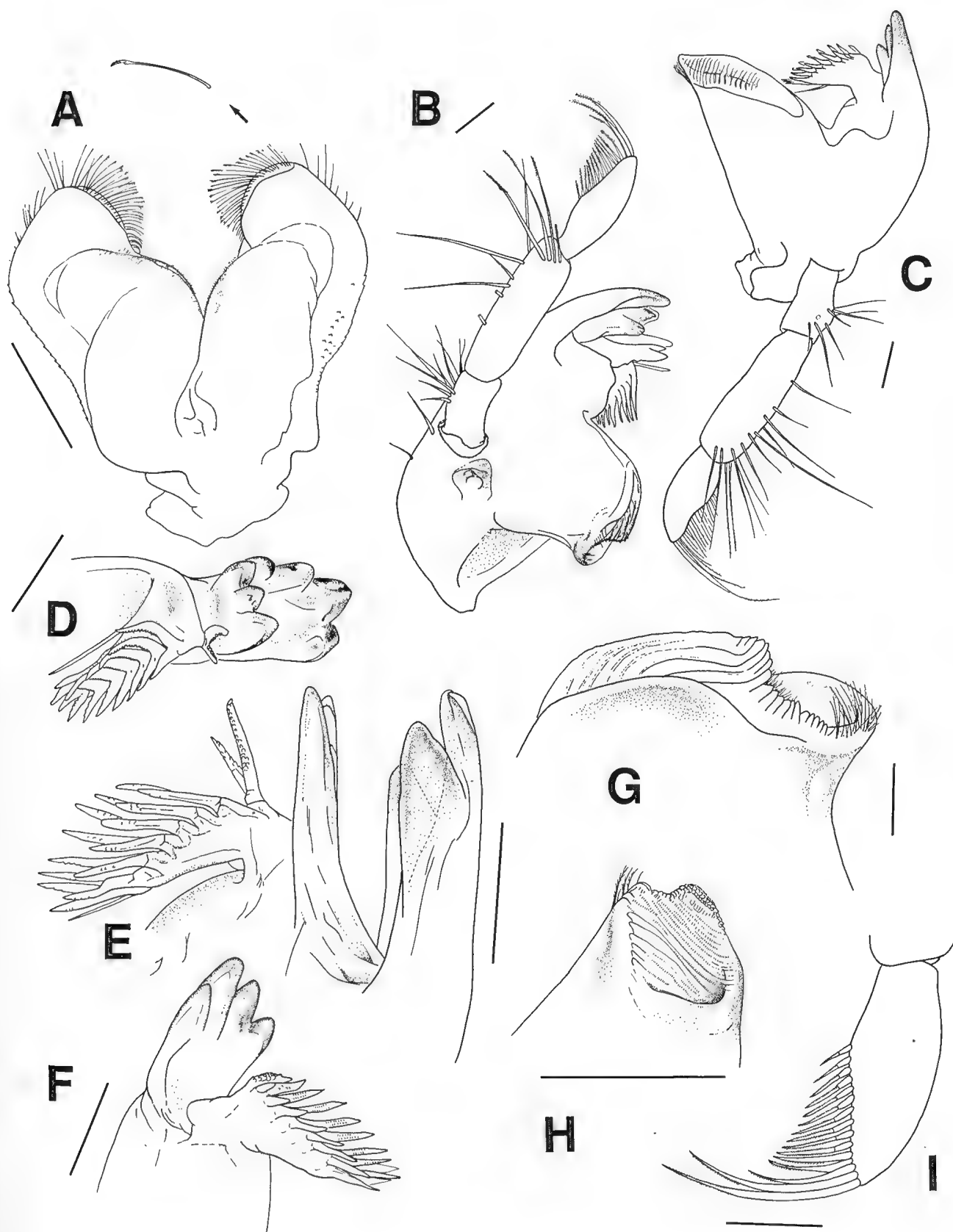


Fig. 8. *Crenoicus buntiae* n.sp. mouthparts. AM P44349, adult male, bl 10.8 mm. A, paragnaths, ventral view. B, left mandible, dorsal view. C, right mandible, dorsal view. D, E, left incisor, lacinia and spine row, medial and ventral views. F, right incisor process and spine row, ventral oblique view. G, H, left molar process, dorsal and ventral views. I, left palp article 3. Scale bar 0.1 mm.

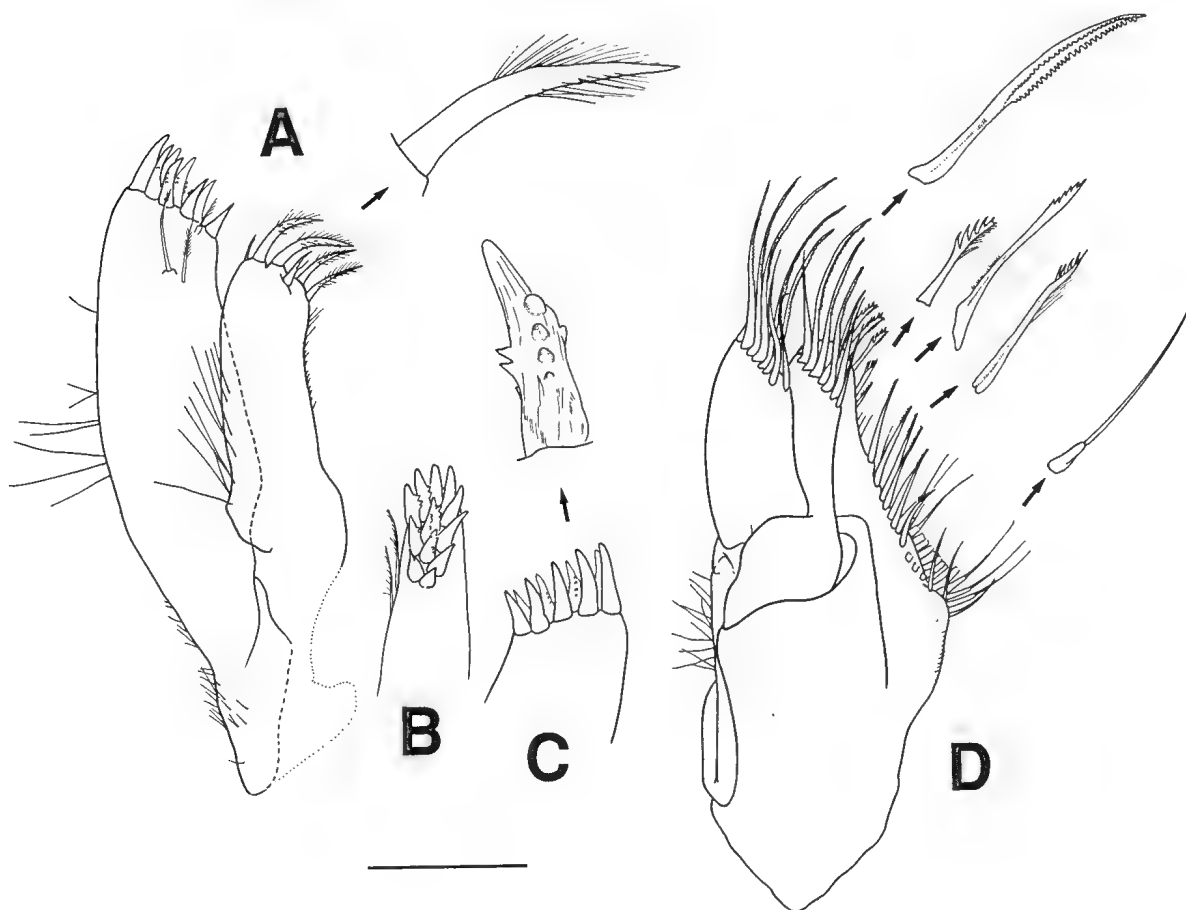


Fig. 9. *Crenoicis buntiae* n.sp. mouthparts. AM P44349, adult male, bl 10.8 mm. A-C, left maxillula, ventral view with enlargement of pappose seta, medial and dorsal views of lateral lobe with enlargement of denticulate seta; D, left maxilla with enlargements of various setal types. Scale bar 0.1 mm

pleotelson length, lateral lobes shorter than median lobe in dorsal view. Tailpiece lateral lobe with 1 strong sensillate setae, median lobe with 4 robust sensillate setae. Dorsal uropodal cleft present, with several fine setae. Ventral margin anterior to uropods with 4-5 strong setae.

**Antennula** (Figs 5, 6A-C). Length 0.1-0.13 body length, with 7-8 articles in adult females, 9-10 articles in largest adult males. Articles 4 distinctly shorter than article 3. Article 6 sometimes dividing into two articles. Single tiny aesthetascs on article 6 to terminal article distally. Terminal article approximately oval, shorter than penultimate article, length 1.2-1.4 width.

**Antenna** (Figs 5, 6A,D) length 0.46 body length in male, 0.38 in female. Flagellum length 0.70-0.73 antenna length, with 24-25 articles in largest males, 14-16 in females. Proximal propodal article absent, antennal scale absent on article 3. Article 5 subequal to article 4; article 6 subequal to articles 4 and 5.

**Mouthfield** (Fig. 6E,F). Clypeus consisting of broad bar, rounded laterally at mandibular fossae, width 0.69 head width. Labrum ventrally semicircular in anterior view, approximately same width as clypeus. Paragnaths (Fig. 8A) with distolaterally rounded lobes having medial setal row and thickened medial base covered with

cuticular spinules.

**Mandible** (Fig. 8B-I). Palp length 0.88 mandibular body length; article 3 with (15-16) setae, setae finely setulate, lacking cuticular hairs or combs; articles 1-2 with groups of long setae (longer than half article length) on dorsolateral margins. Incisor process with 4 teeth or cusps, 3 distally and one on ventral margin. Left lacinia mobilis with 3 teeth or cusps. Right lacinia mobilis absent. Spine row on projection with 9 bifurcate spines on both sides, distalmost spine distinctly separated from remaining spines. Molar process stout, heavily keratinised, broader than long; triturating surface heavily ridged with single posterior rounded tooth and posterior row of fine simple setae.

**Maxillula** (Fig. 9A-C). Medial lobe length 0.75 lateral lobe length; medial lobe 0.77 width lateral lobe width. Medial lobe with 4 plumose seta and 2 distally denticulate "accessory" setae, one on distolateral margin and one between central plumose setae. Lateral lobe with 12 stout denticulate setae, ventral face with three thin distally plumose setae, 2 proximal and one adjacent to stout denticulate setae.

**Maxilla** (Fig. 9D). Medial lobe width subequal to width of lateral lobes, extending anteriorly approximately same distance as lateral lobes. Lateral lobes with 7-8

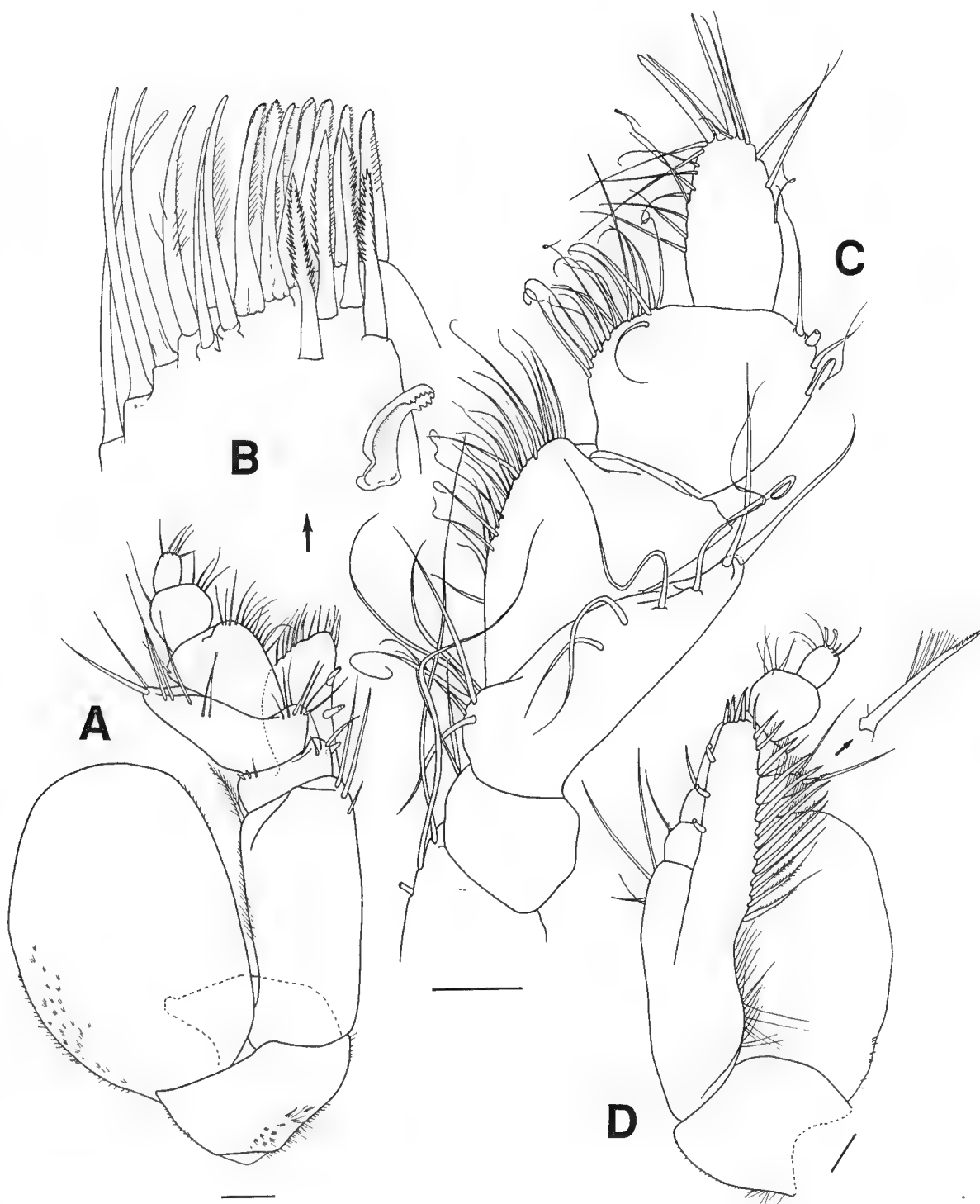
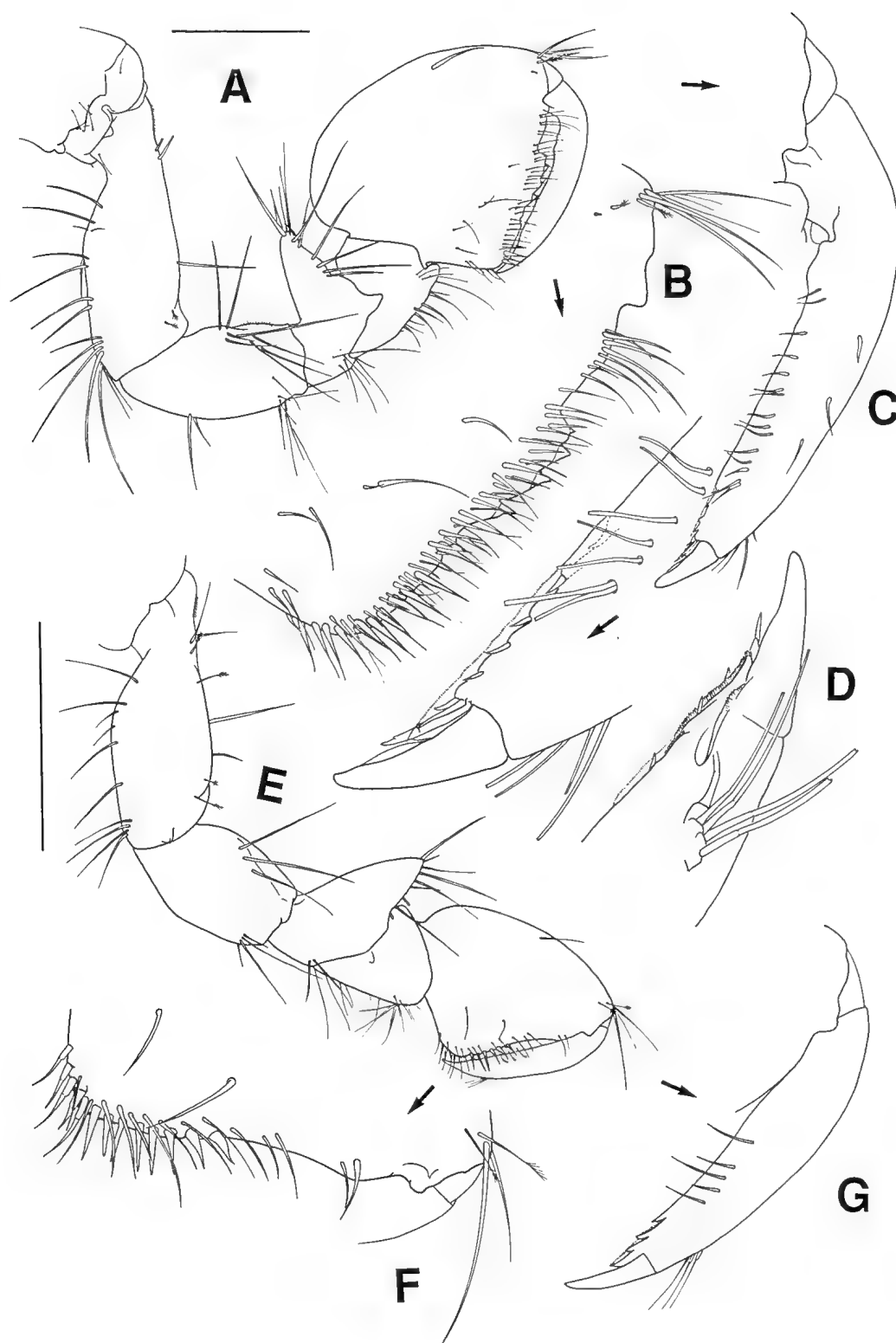


Fig. 10. *Crenoicus buntiae* n.sp. maxillipeds. A, D, P44395, adult male, bl 6.5 mm. B, C, AM P44349, adult male, bl 10.8 mm. A, left, ventral view. B, enlargement of endite ventral view. C, right palp, ventral view. D, left, medial view showing pappose denticulate setae on dorsal ridge. Scale bar 0.1 mm.

setae having two rows of denticles each. Medial lobe with two basal rows of setae separated from single distal row by distinct gap but otherwise smoothly continuous; setae in ventral basal rows with single row of fine setules; setae in dorsal basal row with distinct base and smooth shaft; setae in distal row with row of teeth and row of fine setules.

*Maxilliped* (Fig. 10). Epipod length 1.5 width, distal tip rounded, ventral surface and margins lacking setae, with lateral group of fine cuticular combs. Endite length 0.36 total basis length; distal tip with 4 subdistal biserrate setae on ventral surface; 3 coupling hooks (receptaculi) on medial margin; dorsal ridge with approximately 14 large, distally denticulate plumose



**Fig. 11.** *Crenoicus buntiae* n.sp. pereopods I, lateral views. A–D, AM P44349, adult male, bl 10.8 mm. E–G, P44351, preparatory female, bl 8.5 mm. A, E, right pereopods. B, F, palm of propodus. C, G, dactylus. Scale bar 0.5 mm.

setae. Palp insertion on basis with 1 plumose setae laterally, and 3 simple setae medially. Palp length 0.31 basis length, width (across article 2 & 3) 1.8 endite width; palp article 4 subcircular, length 1.1 width; palp article 5 length 0.87 width, length 0.8 article 4 length.

*Pereopod I* (Fig. 11). Sexually dimorphic, length 0.32 body length in adult male, 0.25 in preparatory female. Pereopod of juvenile males resembling female condition. Dactylus length subequal to palm length in both sexes; row of fine setae along lateral axis; ventral margin with



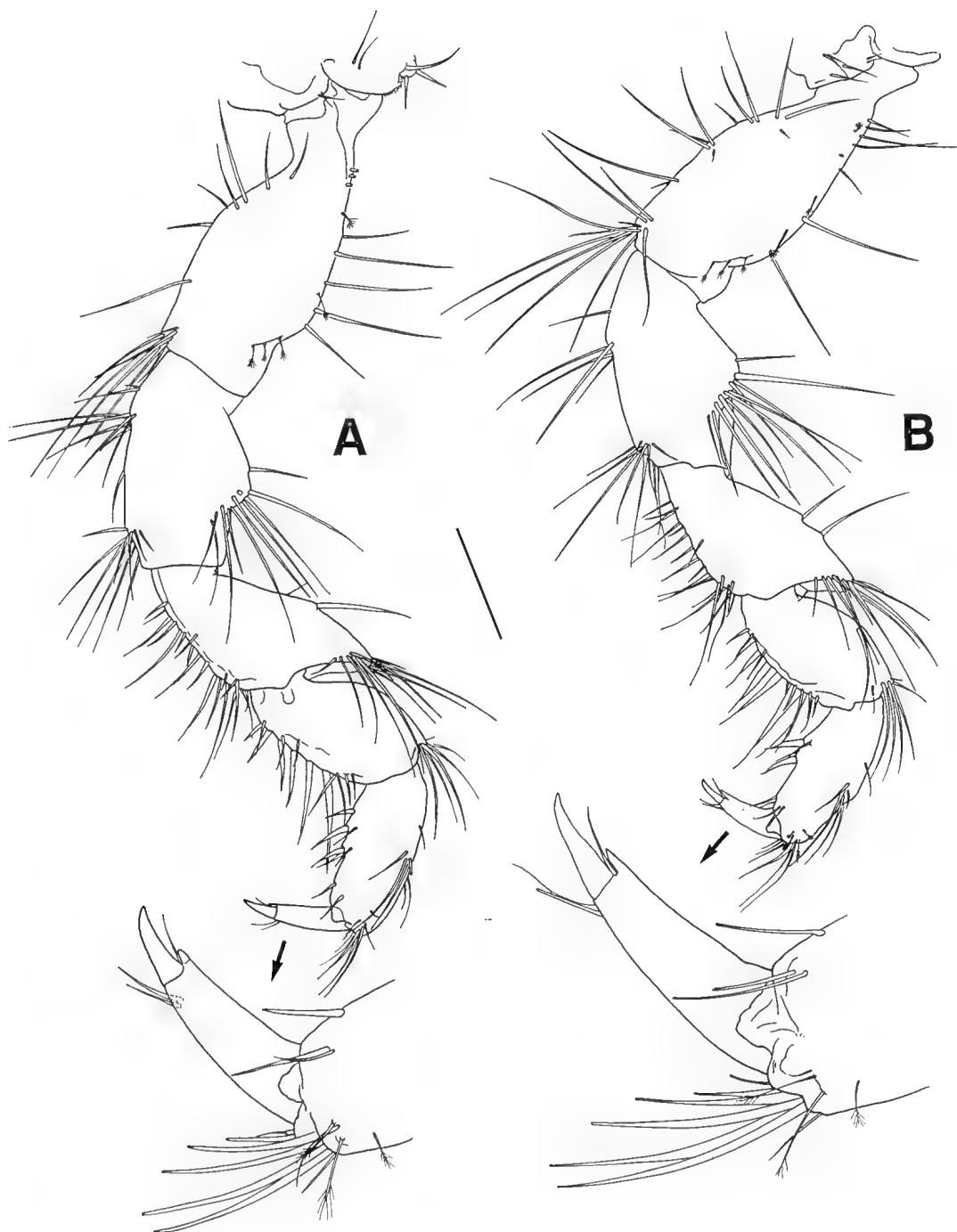


Fig. 12. *Crenoicus buntiae* n.sp. anterior pereopods. P44349, adult male, bl 10.8 mm. A, B, pereopods II–III, lateral view. Scale bar 0.4 mm.

curved setae and distal cuticular fringe; fringe length 0.14 total protopod length in male, 0.20 in female; dactylar distal tip with one large dorsal claw and 1–2 small accessory setae ventrally. Propodus length 0.24 pereopod length in adult male, 0.20 in female; length 1.0 width in adult male, 1.3 in female, dorsal margin protruding more in male. Propodus dorsal margin in male broadly rounded with proximally protruding section; in female, dorsal margin smoothly curving, not expanded

proximally. Propodal palm without elongate spines or projections in both sexes. Propodal palm in male convex with 10–12 stout setae, 4 keratinised tooth-like setae on low humps and fringe of fine setae lateral to stout setae extending from dactylar insertion to ventral angle of palm. Propodal palm in female concave with 12–13 stout setae, no keratinised tooth-like setae and fringe of fine setae lateral to stout setae extending only half length of propodal palm. Basis length 2.5 width in males, 2.5

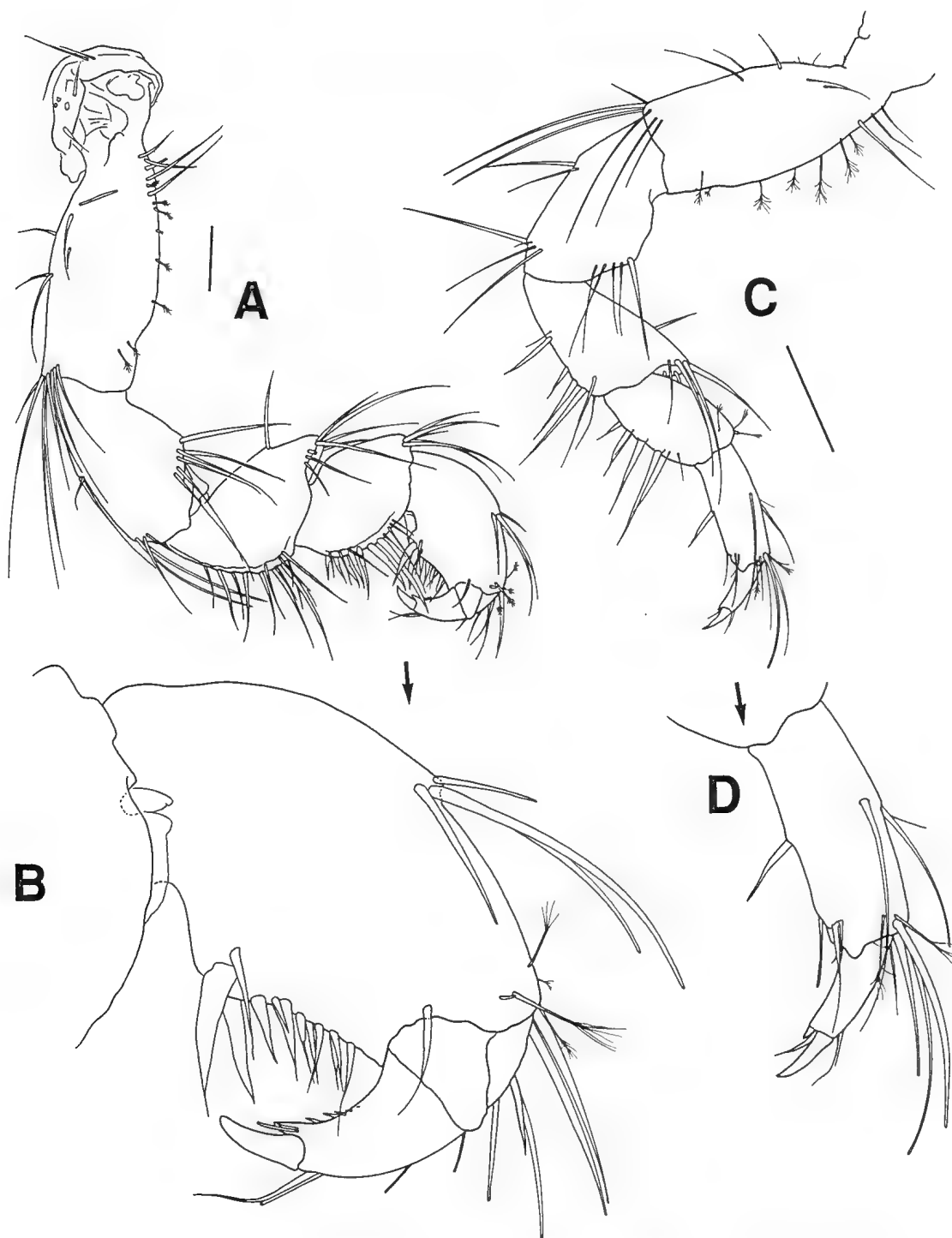


Fig. 13. *Crenoicus buntiae* n.sp. pereopods IV, with enlargements of dactylus and propodus, lateral view. A, B, AM P44349, adult male, bl 10.8 mm. C, D, P44351, preparatory female, bl 8.5 mm. Scale bar 0.2 mm.

in females; dorsal margin with 2–4 elongate setae positioned proximally; ventrodistal margin with group of 4–7 elongate setae distinctly shorter than ischium.

*Pereopod II, III* (Fig. 12). Length 0.32, 0.32 body length. Basis length 0.29, 0.30 pereopod II, III length; length-width ratio 2.5, 2.3; dorsal ridge with 7–9 large simple setae and scattered penicillate setae. Carpus 0.13, 0.13 pereopod length; length-width ratio 1.5, 1.5; margin with 6, 6 broad based setae. Propodus length

0.14, 0.14 pereopod length; length 2.1, 2.1 width; articular plate present on distolateral margin; ventral margin with 2–3, 2 broad based setae. Dactyli distal tip with ventral spine adjacent to claw.

*Pereopod IV* (Fig. 13). Sexually dimorphic, male pereopod IV subchelate with major hinges dactylus-propodus and propodus-carpus. Length 0.28 body length in male, 0.20 in female. Penicillate setae in male on dorsal margin of basis and anterodorsal margins of

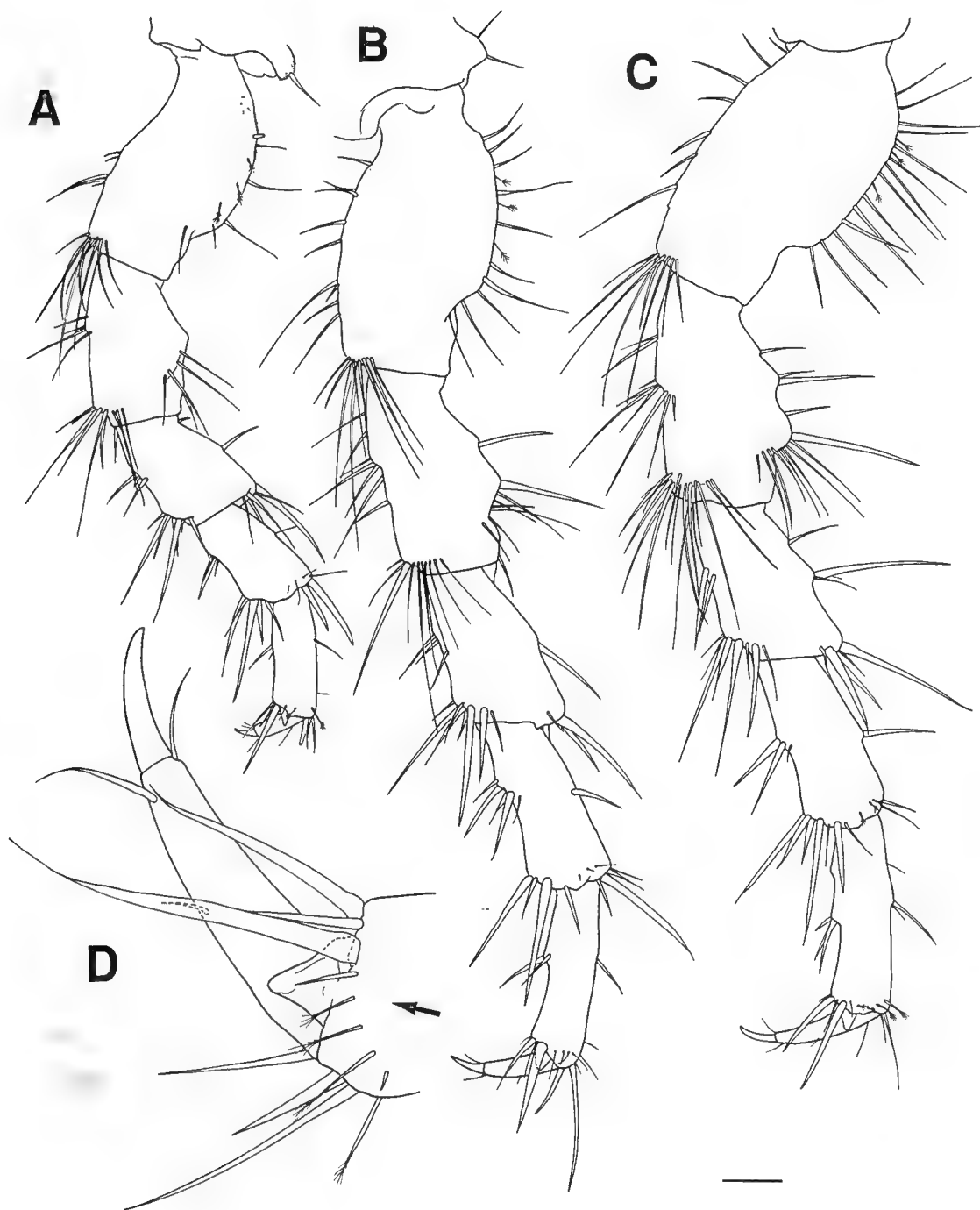


Fig. 14. *Crenoicus buntiae* n.sp. posterior pereopods. P44349, adult male, bl 10.8 mm. A–C, pereopods V–VII, lateral view. Scale bar 0.2 mm.

Propodus, in female on dorsal margin of basis and anterodorsal margins of carpus and propodus. Dactylus in male subequal to propodal palm, with distal accessory spines in both sexes approximately one third length of primary claw in male, one fourth in female. Propodus length 0.14 pereopod length in male, 0.13 in female; articular plate present on posterior side of limb, length subequal to dactylar claw in male, shorter in female; approximately 9 broad based setae on ventral margin

in male, two distinctly larger than others; female with only 1 broad based setae on ventral margin. Carpus length 0.13 pereopod length in male, 0.12 in female; approximately 7 broad based setae on ventral margin in male, 4 in female. Basis length 2.8 width in males, 2.6 in females; dorsal ridge rounded in cross section, with 3–5 setae positioned proximally.

*Pereopods V, VI, VII* (Fig. 14). Length 0.25, 0.34, 0.36 body length. Penicillate setae present on dorsal

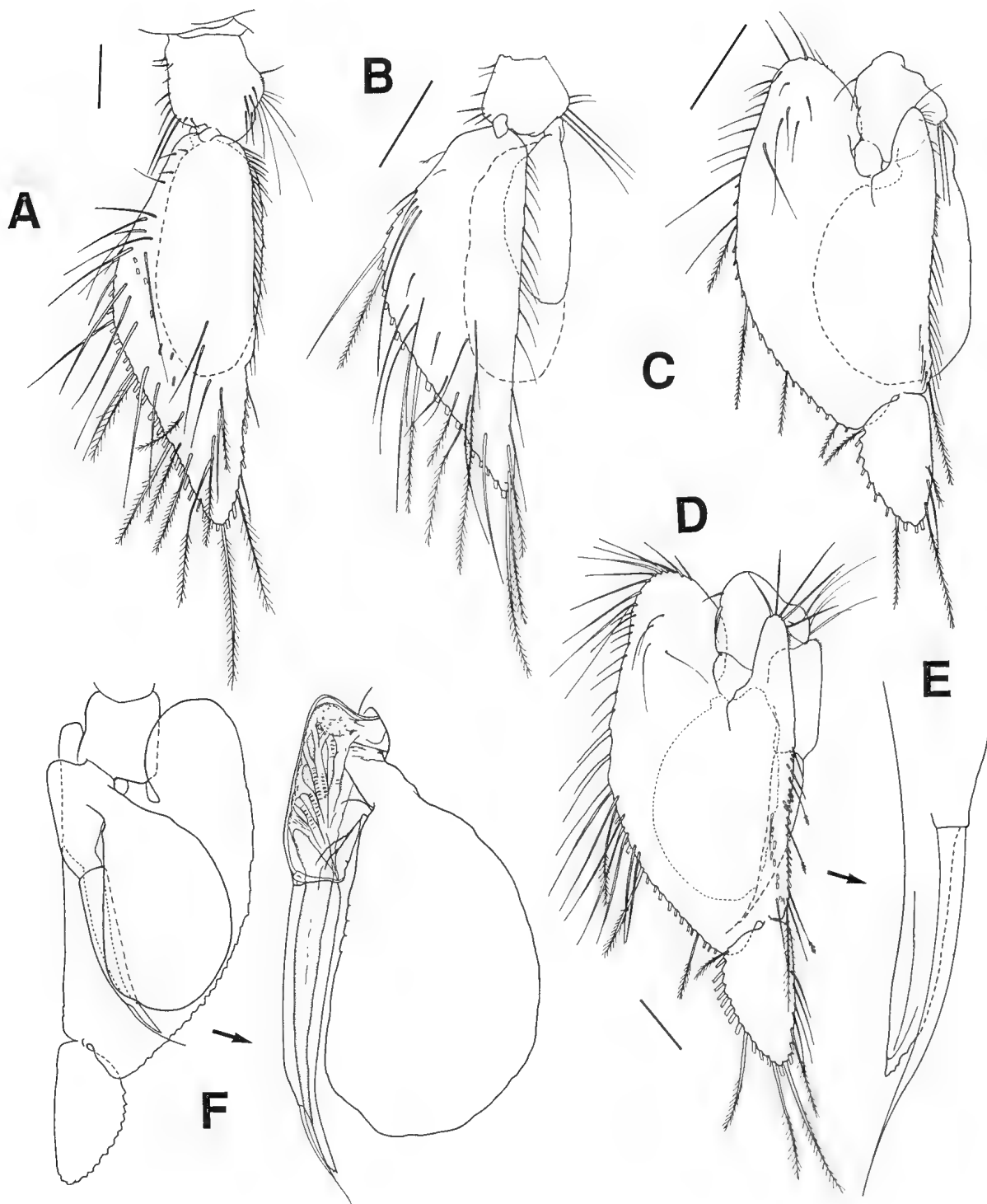


Fig. 15. *Crenoicis buntiae* n.sp. pleopods I-II. A, C-F, P44349, adult male, bl 10.8 mm. C, D, P44351, preparatory female, bl 8.5 mm. A, B, pleopod I, ventral view. C, D, pleopods II, ventral view. E, pleopod II endopod distal tip, ventral view. F, pleopod II, dorsal view with enlargement of endopod. Scale bar 0.2 mm.

ridge of basis, dorsodistal carpus, dorsodistal propodus. Dactylar claw length 0.38, 0.33, 0.30-dactylar length, distal accessory spines absent. Propodus length 0.14, 0.16, 0.16 pereopod length, articular plate on posterior side of limb present; distal margins with 2-4 elongate robust setae. Carpus length 0.14, 0.16, 0.16 pereopod length. Basis length 1.8, 1.6, 1.7 width; dorsal ridge

not distinctly separated from basis shaft, in cross section rounded, with approximately 5, 10, 15 setae positioned along ridge.

*Penes* (Fig. 7C-D) strongly curved posteriorly, length 0.4 body width at pereonite 7, extending past midline and onto pleonite 1, shaft smooth, without setae, tapering, distally rounded.

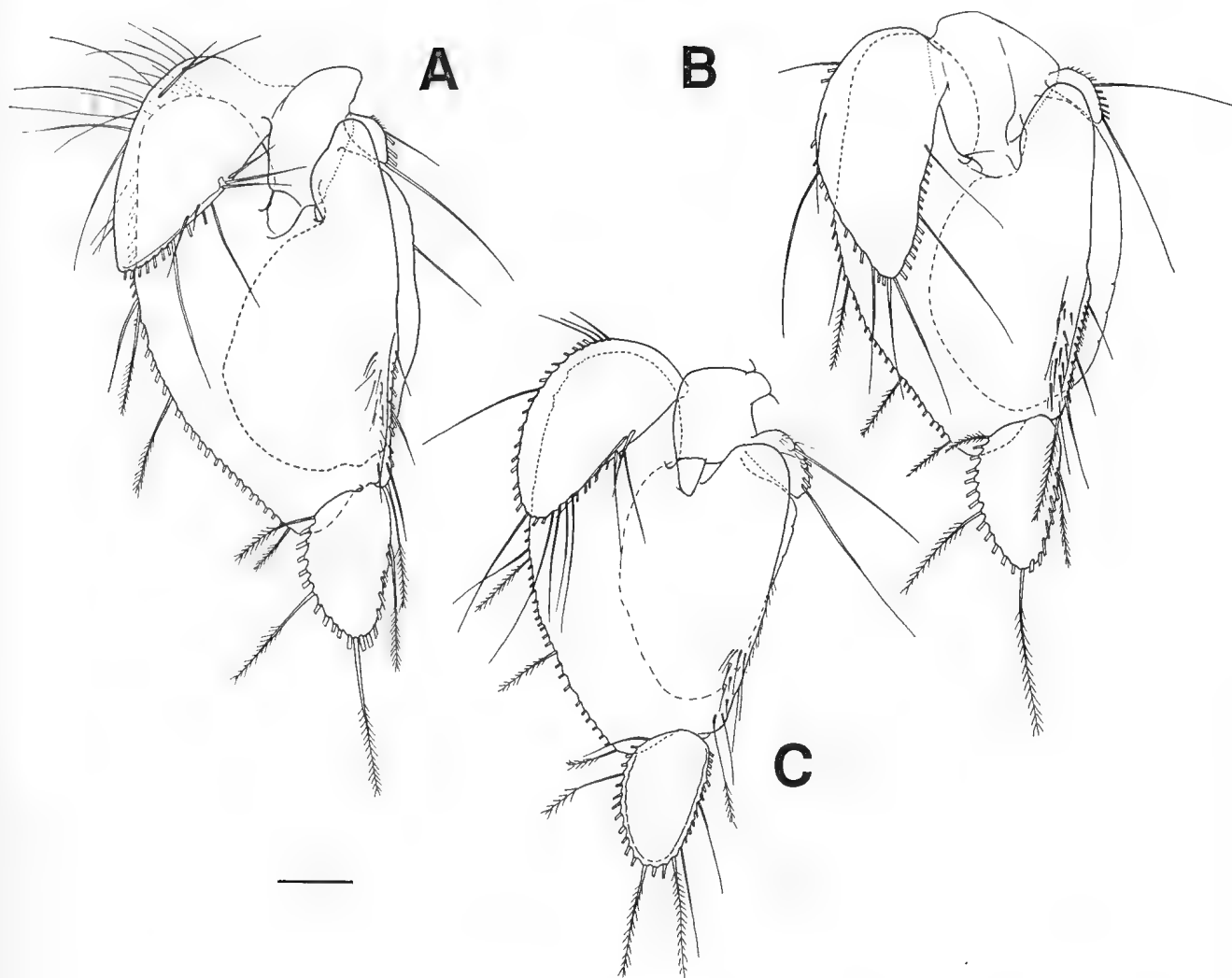


Fig. 16. *Crenoicis buntiae* n.sp. posterior pleopods. P44349, adult male, bl 10.8 mm. A–C, pleopods III–V, ventral view. Scale bar 0.2 mm.

*Pleopods I–V* (Figs 7C, 15, 16). Pleopods I–V lengths 0.15, 0.15, 0.15, 0.14, 0.13 body length in male; pleopods I–III lengths 0.11, 0.12, 0.10 body length in female. Exopods I–V length 2.6–2.7, 1.8–2.2, 1.5–1.7, 1.6, 1.6 width; exopod I uniarticulate; exopods II–V biarticulate, distal articles II–V length 0.36 [ $n = 2$ ], 0.33–0.35, 0.37, 0.34 exopod length; exopod I with no lateral proximal lobes, exopods II–V with medial and lateral proximal lobes. Endopods I–V unilobed; length 2.4, 1.6–1.8, 1.6–1.8, 1.8, 1.4 width; length 0.59, 0.58–0.62, 0.69–0.54, 0.79, 0.60 exopod length; marginal setae absent. Protopods II–V with medial epipods, protopods III–V with lateral epipods. Pleopod I exopod in both sexes broadest at mid length, distally pointed, laterally broadly angular. Pleopod II endopodal appendix masculina (stylet) of male weakly curved, basal musculature pronounced; distal tip spatulate with 1 distal seta, length 0.38 pleopod II length.

*Uropod* (Fig. 7E–G). Total length 1.2 pleotelson length. Protopod length 0.32 width, length 0.47 uropod length; dorsomedial ridge not produced, dorsomedial

ridge setae present, dorsolateral margin setae present, 1 robust distally spinose setae on distoventral margin. Rami distal tips pointed and entire (terminal setae absent), cross-sectional shape round; endopod subequal to protopod length, with no robust setae on dorsal margin; exopod 0.76 endopod length, exopod with 1 robust seta on dorsal margin.

**Remarks.** *Crenoicis buntiae* differs from *C. harrisoni* (see diagnosis for details) in the form of the mature male pereopod IV, with *C. buntiae* having a more typical limb (compare Figs. 4C,D and 13A,B). The second pleopod endopod also differs in males, and the maxillipedal epipod is also useful for identifying females or juveniles. The maxillipedal and pereopod IV setation can be used to separate *C. buntiae* from the Victorian species, with *C. mixtus* having many more setae on the pereopod IV ischium and *C. shephardi* having an obtusely pointed maxillipedal epipod. Certainty in identifying species of *Crenoicis* requires the inspection of adult males.

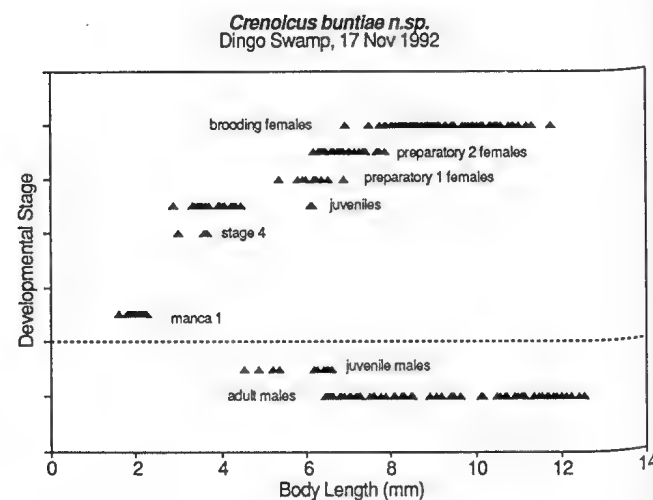
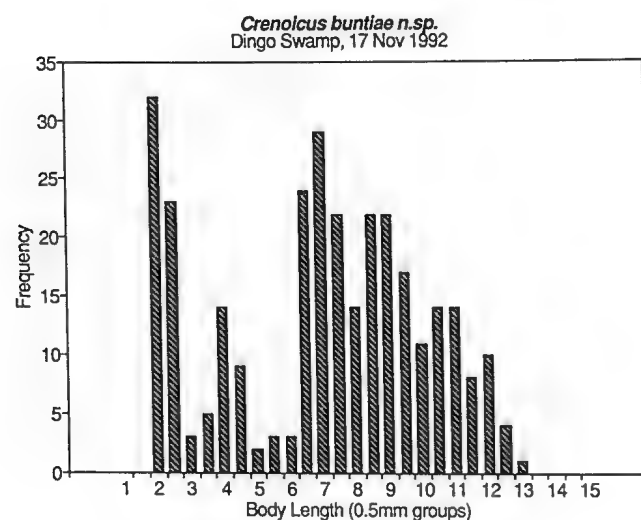
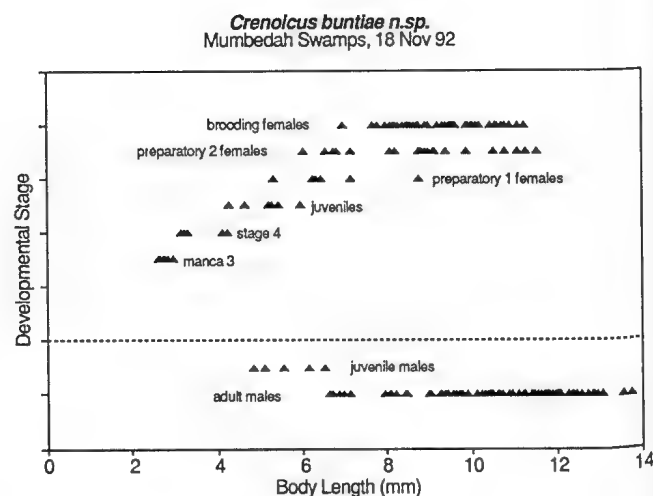
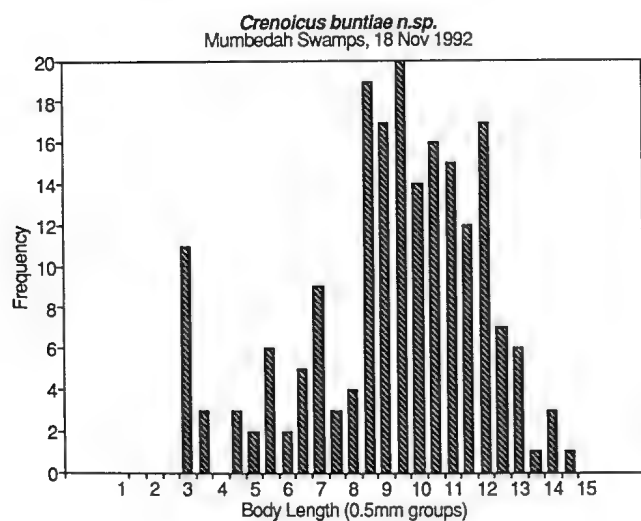
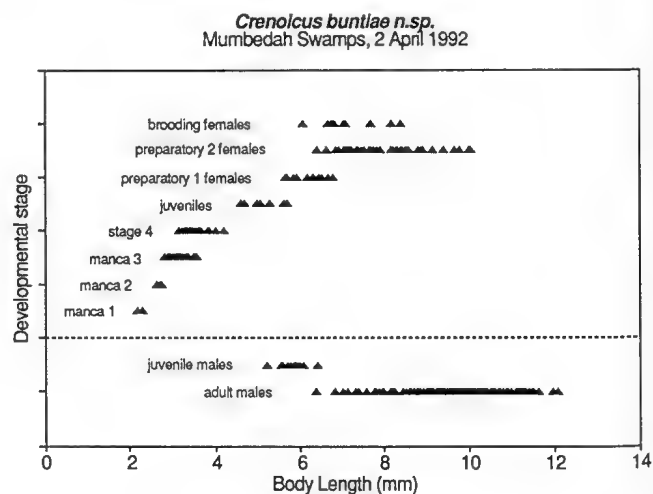
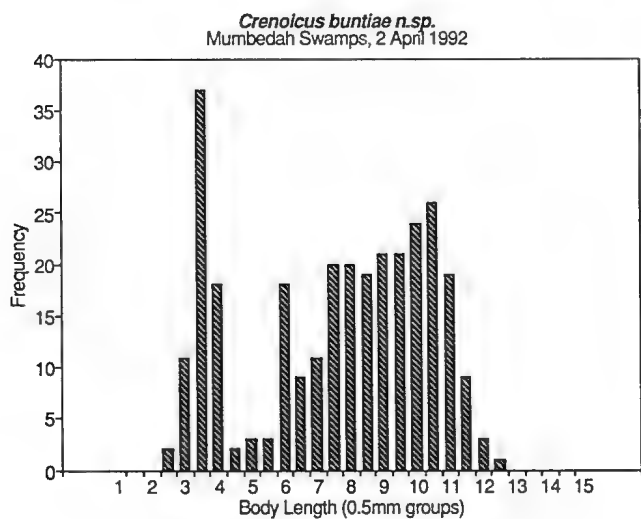
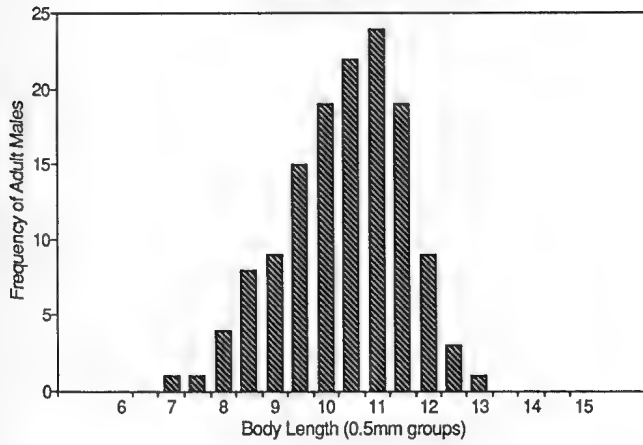


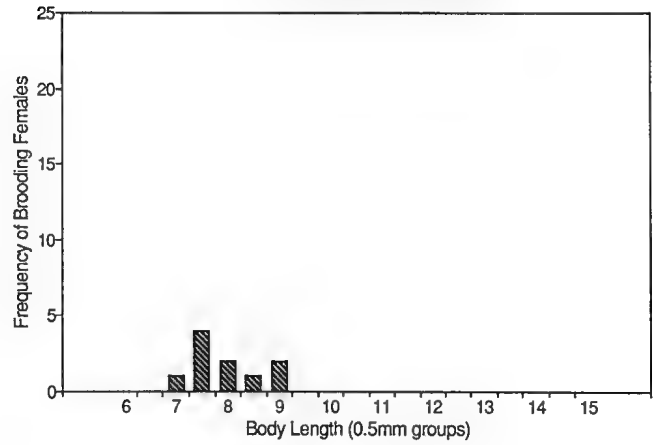
Fig. 17. *Crenolcus buntiae* n.sp. body length frequency classes.

Fig. 18. *Crenolcus buntiae* n.sp. size range of developmental stages.

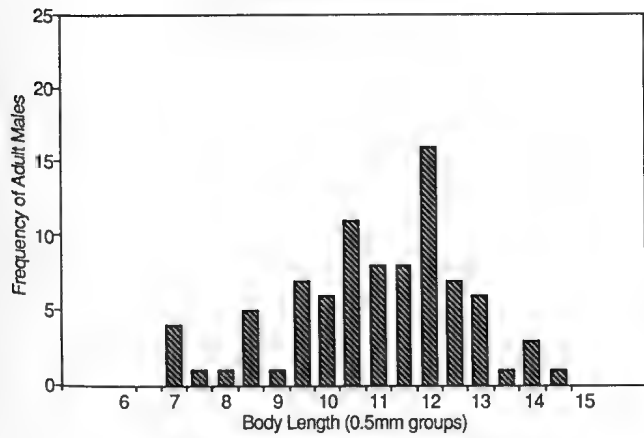
*Crenoicis buntiae* n.sp.  
Mumbedah Swamps, 2 April 1992



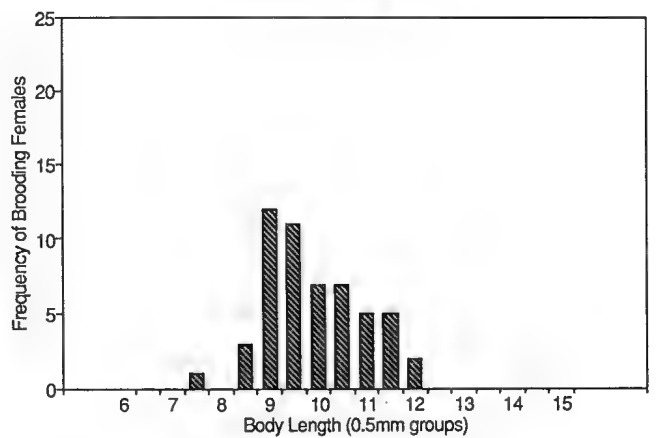
*Crenoicis buntiae* n.sp.  
Mumbedah Swamps, 2 April 1992



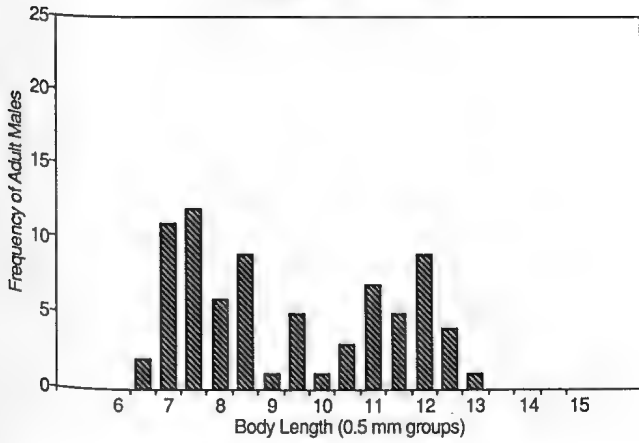
*Crenoicis buntiae* n.sp.  
Mumbedah Swamps, 18 Nov 92



*Crenoicis buntiae* n.sp.  
Mumbedah Swamps, 18 Nov 92



*Crenoicis buntiae* n.sp.  
Dingo Swamp, 17 Nov 1992



*Crenoicis buntiae* n.sp.  
Dingo Swamp, 17 Nov 1992

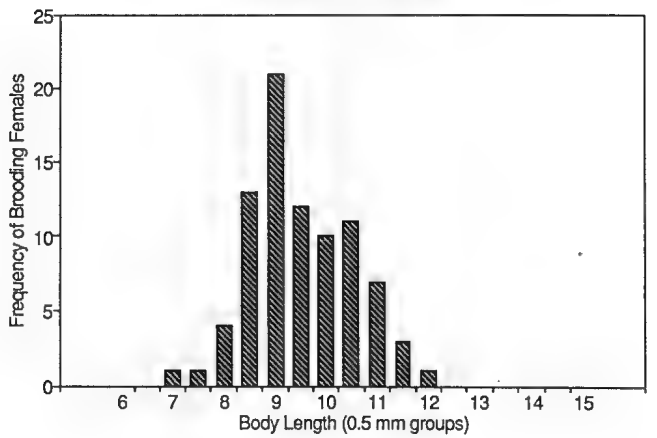


Fig. 19. *Crenoicis buntiae* n.sp. body length frequency classes of adult males.

Fig. 20. *Crenoicis buntiae* n.sp. body length frequency classes of brooding females.



**Small scale geographic variation.** The description given above for *Crenoicus buntiae* n.sp. applies primarily to the populations found at Mumbedah Swamps, and is accurate for most non-cavernicolous specimens found on the Boyd Plateau. The description was taken from the holotype and paratypes that were dissected (see P numbers and figure captions). Populations on the Boyd Plateau can vary geographically in the relative proportions of particular characters. Although we have not made an exhaustive study of variation, some features differed among the sites (see Material Examined above). Populations at nearby localities (Belarah Swamp and Luther's Creek) showed the same variation seen at Mumbedah Swamps, and are not mentioned further.

The illustrated types lacked a robust seta positioned midlength on uropodal endopod (compare Figs 4G [identical to condition in *C. buntiae*] with 7G), while other mature specimens of the Mumbedah population had approximately equal numbers with and without this seta. Those with the seta varied in setal size, without regard to body size. All specimens at Roly Whalen Swamp and most specimens at "Oldmeadow Swamp" had a seta on the uropodal endopod. At Jensen's Swamp, on the other hand, few specimens had a stout seta on the endopod. Assuming that this variation is not an environmental phenotypic response, these data suggest that the populations at Jensen's Swamp and Roly Whalen Swamp may not intermix. This lack of mixing is surprising because the two populations are separated by only a low hill and less than a kilometre.

The propodal palm of pereopod II in adult specimens from Mumbedah Swamps had only 4 setae with a distinct gap between the distal two setae (Fig. 12A). A few specimens at this locality, however, had 5 setae at this position. At Dingo Swamp, many specimens had a pereopod II palm that lacked a gap and had 5 setae. Other sites showed mixtures of this situation. Five or 6 setae on the palm with no gap is a feature that is characteristic of *C. harrisoni*.

The propodal palm of the male pereopod IV varied in shape and position of 3 proximal broad-based setae (Fig. 13B). Most specimens at Mumbedah Swamps had these three setae in a row that was approximately parallel to the axis of the palm. In many specimens at Dingo Swamp, this row of three setae was rotated at an angle to the axis of the palm and the cuticle bearing the setae projected distinctly from the line of the palm. A reinspection of the Mumbedah Swamps population showed that a few adult males also had this condition. Males at Jensen's Swamp lacked this projecting condition, while some males at Roly Whalen Swamp had the three broad-based setal row at nearly a 90° angle to the axis of the palm.

**Council Creek population.** Most localities on the Boyd Plateau had specimens that attained maximum sizes of 12–14 mm in November, 1992. The largest size in April 1992 was smaller (maximum just over 12 mm), and less of the population was fully mature. The specimens collected in November 1992 near Council Creek (P44481,

NSW 487, N = 136), however, were fully mature and copulatory with a maximum size of 10.1 mm (10 fully mature males observed). At the smallest sizes, manca 1 individuals had a median body length of 1.75 mm (N = 4, range 1.72–1.75 mm), which is distinctly smaller than other sites (Mumbedah Swamps, NSW 758, md bl = 2.2 mm, N = 2; Dingo Swamp, NSW 480, md bl = 1.99 mm, N = 55). The merus of the male pereopod IV was also longer than the propodus, whilst in other Boyd Plateau localities, the merus was subequal to the propodus. Other features showed variation similar to the Mumbedah Swamps population. Because the water flow from the *Sphagnum* swamp into Council Creek was small and near the main road, this population could be under more stress than sites within Kanangra-Boyd National Park. Alternatively, the Council Creek swamp is more isolated from the Park sites, so genetic differentiation may have taken place. We cannot distinguish these (or other) possibilities from a single sample.

**Discussion.** These observations suggest that significant small scale variation exists in the populations of *Crenoicus buntiae* n.sp. on the Boyd Plateau. Our survey shows that localised morphological differentiation may take place on an extremely small scale, e.g., over the distance separating Jensen's Swamp from Roly Whalen Swamp—less than a kilometre. We cannot assign any taxonomic status to these variants because each form is found in most populations in varying frequencies. Indeed, we are uncertain of conspecific status of the populations other than those that occur in Mumbedah Swamps. Whether the variation, especially that seen near Council Creek, is phenotypic or genotypic will require a more detailed morphometric and genetic survey of these populations.

**Microhabitat.** *Crenoicus buntiae* n.sp. and other species of *Crenoicus* are most commonly found in *Sphagnum* swamps, but not in an evenly dispersed fashion. The basal part of the *Sphagnum* must be submerged in clear flowing water, presumably ground water emerging at the surface. Most swamps with phreaticoids were the headwaters of streams flowing away from the highlands. *Sphagnum* without flowing water typically lacked any specimens. The green part of the *Sphagnum* moss exposed at the surface typically lacks phreaticoids, while the subsurface pigmentless or brown decaying parts of the fronds will have specimens. Roots of other plants that may be mixed into the moss, such as sedges and *Myriophyllum*, may also provide a good substrate for the animals. Occasionally mounds of *Sphagnum* along slow flowing brooks or the edge of larger streams will have good assemblages on their interior, at or below the water line. Rarely, small numbers of other species have been found amongst the roots of grass along the margin of larger streams (e.g., above the falls on Guy Fawkes River, NSW). These collections were made after heavy rains, suggesting that the animals may have been washed from larger upstream populations.

### Population Biology

Three samples of *Crenoicus buntiae* n.sp. were classified to life stages and measured for body length, head length and pleotelson length. The sites were Mumbedah Swamps (2 samples: NSW 758, 2 April 1992, N = 298; NSW 485, 18 November 1992, N = 196) and Dingo Swamp (NSW 480, 17 November 1992, N = 306) which are separated by a distance of 10.6 km and are part of different drainages (Cox River and Kowmung River, respectively). The results for all three samples are shown in Fig. 17 (length frequency, entire samples), Fig. 18 (the distribution of life stages), Fig. 19 (length frequency, adult males), and Fig. 20 (length frequency, brooding females). The body length data allow preliminary observations on the population biology of *Crenoicus buntiae* n.sp.

**Life stages.** Young are released from the brood pouch at body lengths between 1.8–2.2 mm and start differentiating into males and females at lengths between 4–6 mm. Maturity may be attained around 6–7 mm, and adults may reach lengths greater than 14 mm in the males, or 12 mm in females. Sex-related differences in sizes are consistently seen in species exhibiting mate guarding, precopula in this case (Ridley, 1983; Veuille, 1980; Wilson, 1991). Although not included in the measurement series, the largest brooding female observed (12.1 mm) was collected near Luther's Creek in sample number NSW 486 (P44480) and whose brood pouch contained nearly full term embryos. From the great disparity in the sizes of the adults and the earliest size of reproduction, we conclude that the females are probably iteroparous.

**Timing of Reproduction.** Brooding females were observed at all sites and times during this study. Males holding females in precopula were observed whenever *Crenoicus* species were collected. Moreover, distinct and narrow size modes of body lengths, which would indicate synchronised pulses of reproduction, do not appear in the data. This species, therefore, appears to reproduce asynchronously throughout the year.

The quantities of adults and young, however, varied in the samples, indicating that the frequency of reproduction may vary on a seasonal basis. The autumn sample (April 1992) had few brooding females of the smaller sizes only, while the spring samples (November 1992) had a broader range of brooding females (Fig. 20). Thus, the rate of reproduction appears to drop off during autumn, while in the spring more animals become fully reproductive. A decided gap also appears in the distribution of the mancas in both spring samples (November 1992), while the autumn sample (April 1992) had all sizes of mancas and juveniles. These data suggest that few young are released during the winter, but recruitment to the population takes place more or less continuously during the warm season.

The two spring samples are not identical in their distributions of mancas (Fig. 18): Mumbedah Swamps

had no manca 1–2 stages, while Dingo Swamp has no manca 2–3 stages, but has numerous manca 1 stages. Moreover, Dingo Swamp had a distinct mode of young males, while Mumbedah Swamps were deficient in the smaller sized males (Fig. 19). The two sites thus appear to be out of synchrony with each other during the spring season.

**Influences on reproduction.** We suspect that these populations of *Crenoicus buntiae* n.sp. are not food limited because they live amongst their locally abundant food source (decaying vegetation). Moreover, asynchronous reproduction both within and between sites indicates that the populations are not cuing their reproduction to any specific environmental parameter, such as day length or rainfall. Nevertheless, we observe strong reproduction during the warm season, with hiatuses in recruitment during the winter. Thus, reproduction and recruitment in this species could be controlled by environmental temperature as a simple rate process. More data on populations and environmental parameters are needed before this can be shown with any certainty. Our preliminary data do not sample the entire seasonal cycle at several sites.

### Summary

Although only four species of *Crenoicus* are now described, this genus will be found to be much more diverse when populations are investigated throughout its range. This study of *C. buntiae* demonstrates that phreatoicid species may exhibit much morphological variation. The population biology of *C. buntiae* indicates that this species might breed year round, but with a peak of reproduction during the warmer part of the year and a hiatus during the winter.

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## Freshwater Amphipods from Barrow Island, Western Australia

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**ABSTRACT.** Amphipods collected from bore-holes and caves on Barrow Island, Western Australia are reported. Seven new species of the family Melitidae, genus *Nedsia* Barnard & Williams, 1995, and one of the family Bogidiellidae, genus *Bogidomma* n.gen., are described. A key to the species of *Nedsia* is provided.

BRADBURY, J.H. & W.D. WILLIAMS, 1996. Freshwater amphipods from Barrow Island, Western Australia. Records of the Australian Museum 48(1): 33–74.

Unlike many other areas of the world, gammarid amphipods have not often been reported as components of Australian subterranean freshwater faunas (Williams, 1986; Holsinger, 1994). Recent reports from Western Australia (Humphreys & Adams, 1991; Knott, 1993; Barnard & Williams, 1995), Tasmania (Horwitz, 1988; Eberhard *et al.*, 1991), New South Wales (Eberhard, pers. comm.), and Queensland (Barnard & Williams, 1995) indicate that there is, in fact, a significant and diverse amphipod component among aquatic stygofauna over a wide area of the continent. Moreover, this diversity appears to extend over the coastally located underground waters (e.g., anchialine caves; Bradbury & Williams, 1996). This communication reports a further eight new species of amphipod taken from underground waters of Barrow Island, Western Australia.

Barnard & Williams (1995) describe a mono-specific melitid amphipod genus *Nedsia* from underground waters of North West Cape, Western Australia. Extensive collections on Barrow Island (geologically, an isolated section of the Cape Range and located some 55 km off the coast of Western Australia at 20°46'S 115°24'E),

reveal eight species within underground water systems there. Several are unique, some damaged, but nevertheless described here. Conditions of collection prevailing on Barrow Island preclude re-examination of some sampling sites as many are temporary boreholes, or the fauna has been destroyed as part of the programme of electrolytic protection undertaken in oil drilling procedures. Seven new hadziid species and one new species of bogidiellid are described. Bogidiellids have not previously been recorded from Western Australia, the only other Australian record being from Heron Island, Queensland (Stock, 1984).

### Methods of Dissection and Description

Methods of dissection and description closely follow those of Williams & Barnard (1988) and Barnard & Williams (1995) except in the use of upper case letters to indicate right or left.

The notation M, with an appended number, indicates the position of an object as a fraction of the distance

from the base to the apex of an appendage; **S**, large spine; **s**, small spine.

A key to the abbreviations used in the figures is as follows: **A**, antenna; **Abd**, abdomen; **acc**, accessory; **C**, coxa; **d**, dorsal; **dact**, dactylus; **E** [in figures only], epimeron (cf. **E** in text, for large seta); **fl**, flake; **flag**, flagellum; **g**, gill; **G**, gnathopod; **Hd**, head; **i**, inner; **juv**, juvenile; **L**, left; **lac**, lacinia mobilis mobilis; **LL**, lower lip; **MD**, mandible; **med**, medial; **mol**, molar; **MP**, maxilliped; **MX**, maxilla; **o**, outer; **O**, oostegite; **opp**, opposite; **p**, palp; **P**, pereopod; **PC**, prebuccal complex; **pl**, plate; **Pp**, pleopod; **R**, right; **sp**, spine; **sq**, square view; **sr**, setae removed (sometimes marked by sockets); **st**, sternal gill; **T**, telson; **U**, uropod; **UL**, upper lip; **UR**, urosome; **1, 2, 3... 7**, first, second, third... seventh article, segment, somite or epimeron (as appropriate).

Setae of the mandibular palp are described using the method of Karaman (1969) and Barnard & Barnard (1983). Lowry & Stoddart (1993) proposed a modification of that scheme which removes many of the discrepancies found in the original. However, as description of the few setae present on the mandibular palp of these taxa does not impinge upon the areas of confusion within the original scheme, nor contradict the new, we have been able to employ conventional terminology.

### Family Melitidae

Barnard & Williams (1995) assigned *Nedsia* to the family Melitidae, within the hadzioid superfamily. The hadziid/melitid group is complex and not clearly defined. Holsinger (1994) groups Melitidae within the Hadziidae, pointing to "considerable taxonomic instability within this group, much of which has apparently resulted from rampant parallelism and excessive homoplasy." We do not wish to add to the confusion over affinities within this group, so accept Barnard & Williams (1995) placement for the present.

The genus displays similarities to eriopisids (Karaman, 1984), particularly in the presence of an elongate second article of the outer ramus of the third uropod, which is uncommon, but does occur elsewhere, for example, in *Pseudoniphargus adriaticus* Karaman, 1955 and *Niphargus longicaudatus* Costa, 1851. Unlike *Eriopisa* or *Psammogammarus*, however, the anterior coxae of *Nedsia* are not significantly reduced, nor is the female second gnathopod hadziid, or the first gnathopod ceradocid as in *Psammogammarus*. Moreover, the mandibular palp is reduced to two articles, although the terminal article is linear as in eriopisids, rather than falcate with distinct D- and E-setae as in *Hadzia*.

### *Nedsia* Barnard & Williams, 1995

*Nedsia* Barnard & Williams, 1995: 197.

**Type species.** *Nedsia douglasi* Barnard & Williams, 1995, by original designation.

**Introduction.** This genus was erected by Barnard & Williams (1995) for a single species collected from North West Cape in Western Australia; only females were represented in the collection. We now redefine the genus, include description of a male specimen of *N. douglasi* and describe seven further *Nedsia* species from Barrow Island, Western Australia.

Modification of the original diagnosis is intended to accommodate: additional dorsal spination of the pleonites, variation in the ratio of lengths of articles of the peduncle of the first antenna and length of the second antenna, variation in the medial setation of the maxillae, asymmetry of the palps of the first maxilla, greater relative length of some coxae with more posterior spines, provision for some variation of length of the inner ramus of the third uropod and division of the telson. Additional diagnostic features include allowance for a symmetrical non-excavate upper lip, presence of three, rather than two, blunt naked spines on the inner plate of the maxilliped, and lack of a contiguous naked tooth spine on the maxillipedal outer plate. Reference to exclusively blunt submarginal setae is deleted, as are variation of the apex of the maxillipedal palp, additional numbers of peduncular setae of the pleopods, equal pleopodal rami, and reduction of the spination of the rami of the first and second uropods.

The species described in this report are congeneric with the hitherto mono-typic genus *Nedsia*. Examination of these new *Nedsia* species led to a review of generic characteristics and a redefinition of the genus. All the Barrow Island species of *Nedsia* display apically dentate palmar spines on the first gnathopod and several also bear posterior hadziid setae on the second gnathopod. Whilst the descriptions (Barnard & Williams, 1995) of *Nedsia* and *N. douglasi* do not make reference to bifid palmar spines, examination of others of the species from North West Cape indicates their presence in all cases. Included in the redefinition is information on sexual differences, since the original description was based only on females; male material is now available.

**Diagnosis.** *Pleonites* with few dorsal spines. *Head*: rostrum weak; lateral cephalic lobes moderately to strongly projecting, very broad; no antennal sinus present; eyes absent. *First antenna*: elongate, longer than antenna-2; ratio of peduncular articles from 3:2:1 to 2.7:2.6:1; accessory flagellum 2-articulate. *Second antenna*: short to very short; flagellum much shorter than peduncle; calceoli absent. *Mandible*: palp reduced, 2-articulate; ratio of mandibular palp articles variable, article-1 not setose, terminal article linear or tapered, subtruncate; setae few or nil C- or D-setae, 2 or 3 E-setae. *Lower lip*: with inner lobes. *Maxillae*: moderately to well setose medially; inner plate of maxilla 1 ovate with variable number of medial setae, outer plate with denticulate spines, palps symmetric or nearly so, with thin apical spines; inner plate of maxilla 2 with row of medial setae extending onto face apically, other medial setae few or absent. *Coxae*: 1-7 mostly short, broader than long, with few or no posterior spines; coxa

1 not expanded below; coxa 4 not excavate posteriorly; coxa 5 as long as 4. *Gnathopods* 1–2 diverse: first gnathopod small, feeble; carpus longer than propodus, not lobate; merus lacking hyaline lobe; palm transverse, spines simple, some bearing trigger hairs and thus asymmetrically bifid, some apically dentate; spines at corner of palm—lateral 2–4 long, medial 2–5 short; setae along palm moderate to sparse and simple; second gnathopod weakly enlarged; carpus short and lobate; propodus of medium enlargement and ovate; palm oblique, irregularly spinose and sparsely setose, defining corner with 1–3 spines. *Pereopods* 5–7 moderately elongate; pereopod 7 longer than pereopods 5–6; article-2 moderately expanded, ovato-rectangular, posteroventrally extended but not lobate; dactyls of pereopods 3–7 lacking accessory spinules. *Coxae*: 2–6 each with flask-shaped gill; coxal gill 6 not reduced; coxae 2–5 each with a thin, poorly setose oostegite. *Thoracic segments*: lacking sternal gills. *Uropod* 3: strongly extended, parviramous; peduncle short; outer ramus 2-articulate, huge; inner ramus scale like, reaching to M0.15–0.25 on article-1 of outer ramus. *Telson*: longer than broad; cleft 90–100%; lobes weakly convex laterally, with subapical setation; setal spines, where present, lateral; single lateral penicillate setules at M0.6 to M0.7 on each side.

**Additional description.** *Upper lip*: symmetrical or asymmetrical; sometimes weakly excavate below. *Mandibles*: accessory blades (rakers) very few (3–4) on right side, with or without interraker plumose setae between each main raker; both mandibles with few or no additional serrations beyond rakers. *Maxillae*: both plates of second maxilla with apical setae of medium length; inner plates of maxillae 1–2 and medial and lateral margins of maxilla 2 poorly covered with

pubescence. *Maxilliped*: inner plate very long with distal row of several plumose setae and 3 blunt naked spines, and short medial row of plumose setae; outer plate large, with few distal plumose setae, continuous with a blunt naked tooth spine in some; medial margin carved into sinuities, spineless; submarginal face with pairs of setae; palp articles 2–3 weakly setose laterally, article-2 moderately setose medially, article-3 with setae or comb rows of setae near the base of the dactyl, apex weakly or not produced, dactyl unguiform, with short to moderate length nail. *Gnathopods*: dactyls lacking inner tooth spine, lacking nail; *first gnathopod* without rastellate seta of article-4. *Pereopods*: 3–4 of proportions similar to pereopods 5–7; posterior spine sets on article-6 of pereopods 3–4 unevenly spaced. *Pleopods*: similar; peduncles with 1–3 setae each; rami extending subequally to equally, basomedial setae of inner rami of some bifid; retinaculæ 2 or 3, no more than one accessory retinaculum present. *Epimera*: posteroventral tooth of epimera 1–3 usually absent; posterior margins smooth, and/or sinuous and sparsely setulose; some bearing facial spines near ventral margin. *Uropods*: apicolateral corner of peduncles on uropods 1–2 with 1 and 2 spines (thus with no more than 1 ventrally displaced spine on uropod 2); dorsal margins with or without spines; medial margin of uropod 1 with 1 or 2 apical spines; rami of uropod 1 extending subequally; outer ramus of uropod 2 shortened; uropod 1 with basofacial spine; most rami of uropods 1–2 with two spine rows, albeit reduced; medial setae of outer ramus of uropod 3. sparse, usually with subdistal peduncular setae or spines. *Urosome*: ventrodistal spine on urosomite 1 at base of uropod 1 absent.

**Composition.** *Nedsia* now contains eight species. All the species recorded here are thought to be marine invaders or “strandings”.

### Key to Species of *Nedsia*

1. Second maxilla with sparse marginal basomedial pubescence on inner plate (e.g., Fig. 3) or no pubescence on either plate ..... 2
- Second maxilla with moderate to dense marginal pubescence both plates (e.g., Fig. 6) ..... 4
2. Pleonites without dorsal spines ..... *N. straskraba*
- Pleonites with dorsal spines ..... 3
3. Epimeron 1 without distolateral spines, peduncle of uropod 1 with a lateral row of short facial spines besides the basofacial and distal spines, the palmar corner of gnathopod 1 rounded, the outer plate of the maxilliped tapering apically and with weak medial cusps ..... *N. fragilis*
- Epimeron 1 with distolateral spines, peduncle of uropod 1 without facial spines besides basofacial and distal spines, palmar corner of gnathopod 1 subquadrate, outer plate of maxilliped not tapering, but rounded apically and with strong medial cusps ..... *N. humphreysi*



4. Posterior margins of pleon sculpted, epimera with facial spines as well as ventral submarginal spines (e.g., Fig. 18) ..... 7
- Posterior margins of pleon smooth, epimera without facial spines other than ventral submarginal spines (e.g., Fig. 8) ..... 5
5. Epimera 2–3 with few ventral submarginal spines, urosomite 1 with a spine-like extension at the base of the first uropod, rami of pleopods with more than six articles, maxillipedal palp article-3 without organised comb rows of setae at base of dactyl ..... *N. hurlberti*
- Not as above ..... 6
6. Coxa 1 with one or more anterior spines, without anterior setae, telson without dorsal setae, length of the maxillipedal outer plate  $2 \times$  width ..... *N. urifimbriata*
- Coxa 1 without anterior spine(s), with anterior setae, telson with dorsal setae, length of the maxillipedal outer plate not more than  $1.6 \times$  width ..... *N. douglasi*
7. Posterolateral margins of pleonite 4 with spines, medial margin of outer plate of maxilliped rugose, with 5 indentations ..... *N. macrosculptilis*
- Posterolateral margins of pleonite 4 without spines, medial margin of outer plate of maxilliped not rugose, with 4 indentations ..... *N. sculptilis*

### *Nedsia douglasi* Barnard & Williams, 1995

*Nedsia douglasi* Barnard & Williams, 1995: 198–201.

**Diagnosis.** *Body*: only pleonite 6 with 2 dorsal spines. Lateral cephalic lobes strongly projecting. *Antennae*: ratio of length of peduncular articles of first antenna = 45:35:8. *Upper lip*: asymmetrical; weakly excavate below. *Mandibles*: accessory blades (rakers) very few (3–4), no additional serrations beyond rakers; mandibular palp 2-articulate, ratio of articles 5:8, article-2 linear, subtruncate, 2 or 3 E-setae. *Maxillae*: inner plates of maxillae 1–2 poorly covered in pubescence; well setose medially; inner plate of maxilla 1 with 6 medial setae, palps symmetric; inner plate of maxilla 2 with no setae other than medial row extending onto face apically. *Maxilliped*: naked tooth spine of outer plate blunt, palp articles 2–3 weakly setose laterally, setae of article-3 organised into comb rows near base of dactyl; nail of dactyl short. *Coxae*: 1–7 short; coxae 1–4 lacking posterior spines. *Gnathopods* 1–2 diverse in female (male unknown); palmar spines of *first gnathopod* asymmetrically bifid, spines at corner of palm = lateral 3 long, medial 4 short; setae along palm sparse and simple; defining corner of *second gnathopod* with 1 spine. *Gills*: coxae 2–4 each with flask shaped gill. *Oostegites*: present on coxae 2–5. *Pleopods*: peduncles

with 1 seta each; retinaculæ = 2, accessory retinaculæ = 1. *Epimera*: posteroventral tooth of epimera 1–3 absent. *Uropods*: apicolateral corner of peduncles on uropods 1–2 with 1 and 2 spines (thus with 0–1 ventrally displaced spines), dorsal margins spinose, medial margin of uropod 1 with 2 apical spines, all rami of uropods 1–2 with 2 spine rows, albeit weakly furnished; inner ramus of uropod 3 reaching to M0.16 on article-1 of outer ramus. *Telson*: cleft 100%; setal spines, where present, lateral; single lateral penicillate setules at M0.6 on either side.

**Description.** As recorded for the holotype (Barnard & Williams, 1995).

A single male specimen was collected from a related site on North West Cape. This specimen, male “c”, bears many similarities to the female holotype and is believed to represent the same species. Variations from the holotype are set out within the description below.

**Material examined.** Male “c”, 5 mm: Cape Range, Western Australia. North West Cape region, subterranean fresh waters of the coastal plain. Western Australian Museum sample BES186. Not from type locality.

**Description of male “c”** (Figs 1, 2). *Body* 5 mm. *First antenna*: ratio of peduncular articles 50:48:18



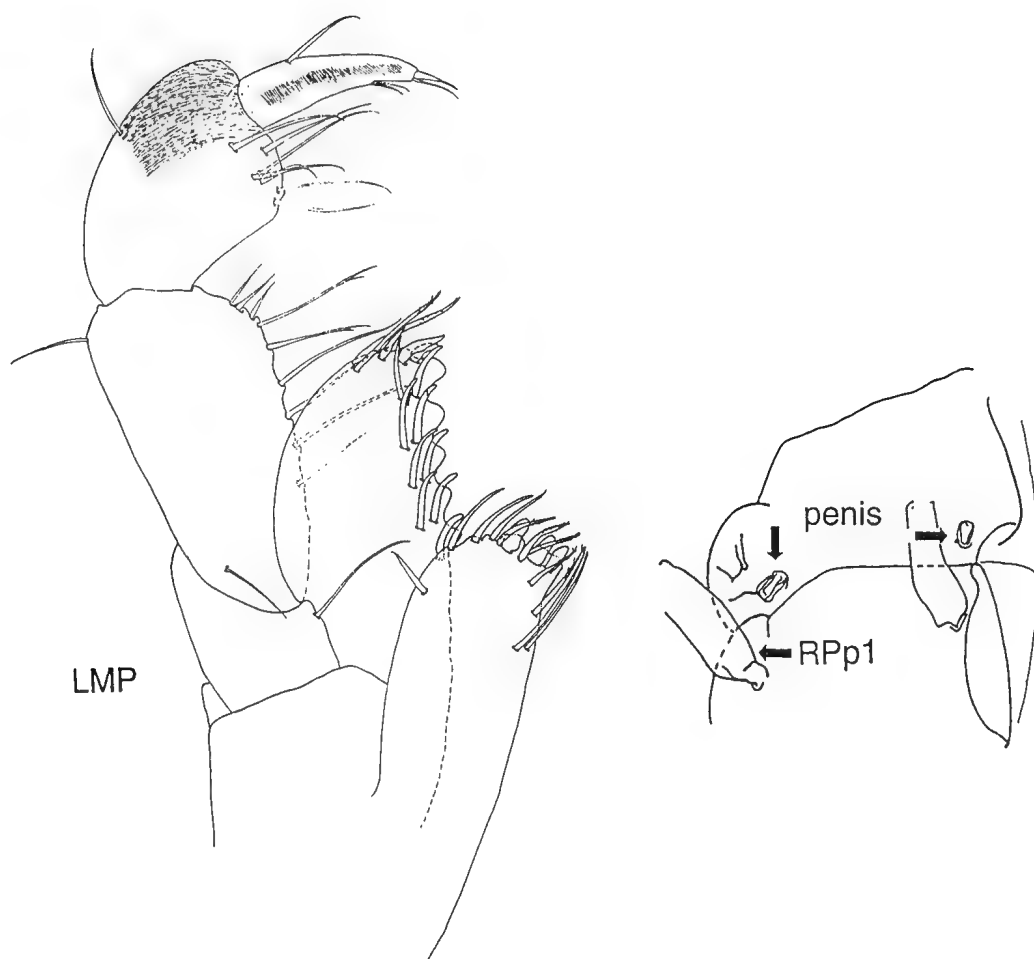


Fig. 1. *Nedsia douglasi* male "c" 5 mm. Maxilliped and penis.

(converts to 45:43:16 compared with female type = 45:35:8). *Upper lip*: apex rounded, not excavate, connection symmetrical. *Left mandible*: palp article-1 shorter than 2; article-2 with 2 apical setae; incisor 5 teeth; lacinia mobilis with 4 or 5 teeth; 5 setose accessory blades. *Right mandible*: incisor with 5 teeth; lacinia mobilis bifid; 4 moderately setose accessory blades. *Maxilliped* (Fig. 1): 3 blunt naked tooth spines on the inner plate. *Gnathopods* (Fig. 2): palm of gnathopod 1 more setose than female type, of gnathopod 2 similar. *Pereopods* (Fig. 2): similar to female type. *Uropods*: lengths relative to uropod 1 = 1:0.6:1.6 (vs. 1:0.5:1.33 in the female type): uropod 1 peduncle 1.14× outer ramus (vs 1.3×); inner ramus 1.14× outer; apices of both rami bearing 4 spines (vs 4–6); uropod 2 rami with marginal spines 1–1 and 1–2 (vs 1–1 and 1–3). *Telson*: fewer dorsal setae than the female type. *Penis*: small penial processes borne on either side of the posterior ventral surface of the seventh thoracic segment (Fig. 1).

**Distribution.** Coastal plain, North West Cape, Western Australia, Western Australian Museum sample BES186.

### *Nedsia straskraba* n.sp.

Figs 3–5

**Etymology.** Named for Milan Straskraba, noted limnologist and early contributor to our knowledge of the taxonomy of Australian freshwater amphipods.

**Type locality.** Barrow Island, Western Australia, Western Australian Museum sample BES531.

**Material examined.** HOLOTYPE (Western Australian Museum WAM 1-96) male "a", 3 mm; male "b", 2.5 mm (collected at same site, at different date. Western Australian Museum sample BES539).

**Diagnosis.** *Pleonite* 6 without dorsal spines. *First antenna*: ratio of peduncular articles about 3:2:1. *Second antenna*: very short. *Upper lip*: margin not excavate; apically rounded and pilose. *Mandibles*: mandibular palp 2-articulate, article-2 cone like, setae 2E or 2D2E; interraker plumose setae absent; no additional serrations

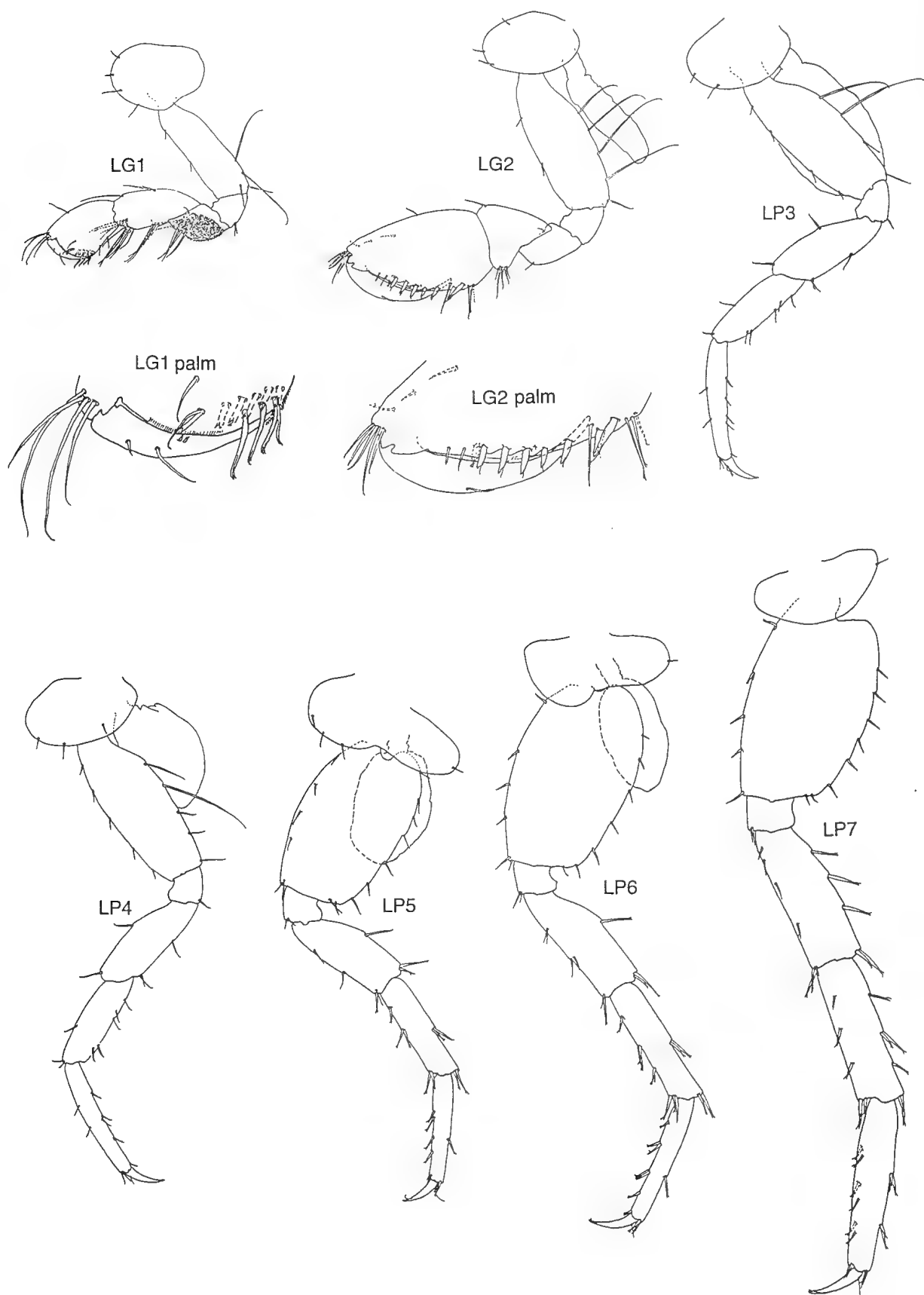


Fig. 2. *Nedsia douglasi* male "c" 5 mm. Legs.

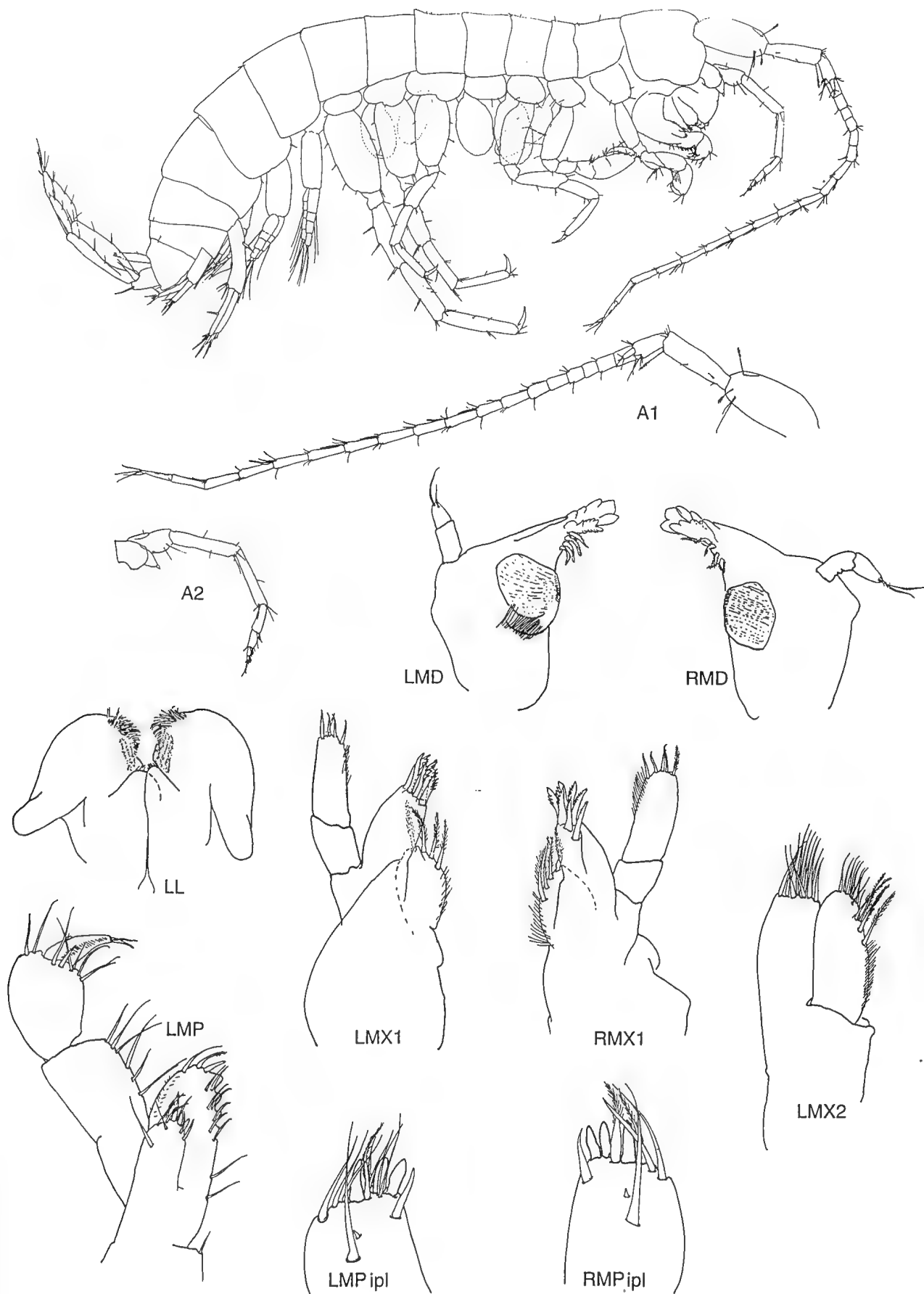


Fig. 3. *Nedsia straskraba* holotype male "a" 2.7 mm. Body, antennae, mouthparts.

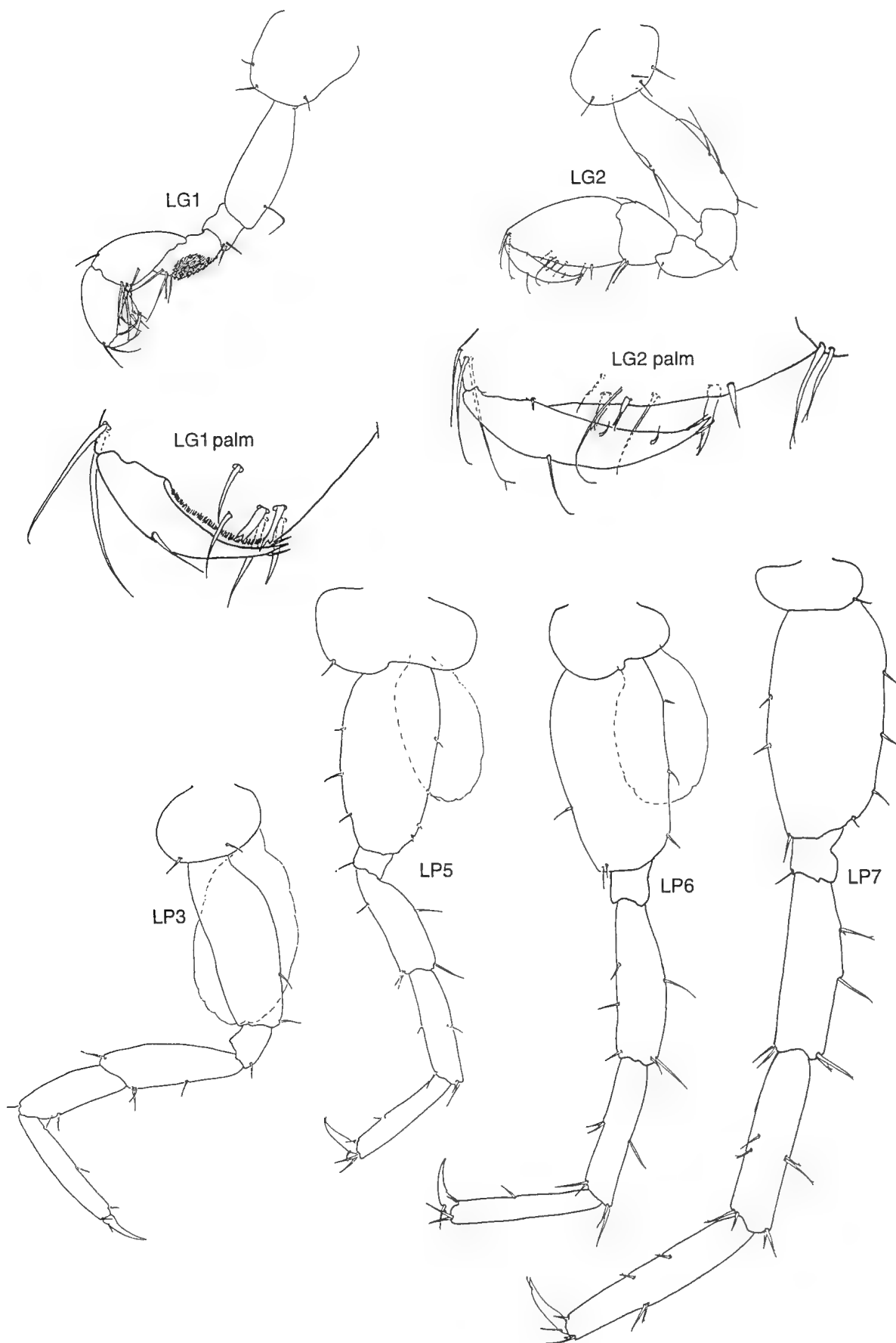


Fig. 4. *Nedsia straskraba* holotype male "a" 2.7 mm. Legs.

beyond rakers. *Maxillae*: moderately setose medially; *first maxilla* inner plate with 4 mediobasal setae; palps almost symmetric. *Maxilliped*: inner plate moderately long, no additional setae (plumose or naked) medially; outer plate with a blunt, naked tooth spine medially, the second pair of submarginal facial setae reduced to a single seta; palp article-3 lacking comb rows of setae near the base of the dactyl, facial comb row of setae from dactylar base to nail, nail of moderate length with similar length distal spine. *Coxae*: coxa 1 not expanded below; coxae 1-2 longer than broad with 1-3 posterior spines respectively; coxae 3-4 lacking posterior spines. *First gnathopod*: palmar spines evenly bifid; spines at corner of palm = lateral 2 long, medial 2 stout and bifid; setae along palm sparse; cutting edge of palm with many fine serrations. *Second gnathopod*: carpus only slightly lobate; defining corner of palm with 2 spines. *Pereopods*: posterior spine sets of article-6 of pereopods 3-4 reduced to 2 spines on pereopod 3. *Gills*: coxal gills 5-6 slightly reduced. *Pleopods*: peduncles with 0 or 1 seta each; rami extending subequally; basomedial seta on inner rami not bifid; retinaculæ 2 on each pleopod, accessory retinaculæ 1,0,1. *Uropods*: apicolateral corner of peduncles of uropods 1-2 each with 1 spine; dorsal margins of uropod 2 naked; spine rows of rami of uropods 1-2 reduced to 1 (uropod 1) and 2 (uropod 2) medial spines. *Telson*: cleft 100%.

**Description of holotype (male "a").** *Body* (Fig. 3) 2.7 mm. *Urosome*: poorly armed dorsally. *Head*: rostrum obsolescent; eyes absent. *First antenna* (Fig. 3): length  $0.9 \times$  body,  $3.2 \times$  antenna-2; flagellum longer than peduncle (470:188); peduncular article-3 shortest, article-1 longest, ratio of lengths = 88:68:32; setae sparse; aesthetascs present on articles 8, 9, 11, 12, 14; calceoli absent; flagellum of 18 articles; accessory flagellum 2-articulate, reaching M0.7 of article-1 of primary flagellum, article-2 tiny; articles of primary flagellum not uniform, sparsely setulate. *Second antenna* (Fig. 3): length  $0.28 \times$  body (206:745); peduncle much longer than flagellum, articles 4-5 equally long, 3-5 with weak ventral setation, article-3 with 1 dorsomedial spine; flagellum 4-articulate, no calceoli. *Upper lip*: margin not excavate. *Mandibles* (Fig. 3): left mandibular palp 2-articulate, articles unequal in length (17:10), article-2 with 2 long apical setae (2E) and 2 short setae (2D); incisor 5 toothed; lacinia mobilis with 4 denticles; 5 setose accessory blades; molar without distal plumose seta (probably lost by damage to specimen), tritritative; no other pubescence; right mandibular incisor 4 toothed; lacinia mobilis bifid, broad, finely denticulate; accessory blades of 5 plumose spines; palp 2-articulate, length ratio of articles 17:10. *First maxilla* (Fig. 3): palp article-2 with 5 thin apical spines, all naked on R, one plumose on left side; outer plate of left with 7 denticulate spines, of right with 6; inner plate bearing 4 terminal plumose setae medially, medial margin pubescent. *Second maxilla* (Fig. 3): outer plate devoid of pubescence; inner plate pubescent on basomedial margin. *Maxilliped* (Fig. 3): nail of palp short (11:32 of dactyl), article-3 with few thin setae at inner edge, none proximal; inner plate with single

ventrofacial spine and short spur at M0.5 and 0.6, and a single submarginal medial naked spine at M0.8. *First gnathopod* (Fig. 4): coxal plate with several short setae apically and one posteroventrally; article-4 slightly bulbous posteriorly, carpus not lobate; propodus trapezoidal, expanding slightly apically, longer than wide, the posterior edge naked, corner of palm rounded, 2 long, naked lateral spines, 2 stout bifid spines medially, palm slightly convex, dactyl reaching beyond the palm. *Second gnathopod* (Fig. 4): palm with 2 medial and 2 lateral spines, all but the corner spines being bifid, and 2 long and 1 medium setae; spines at palmar corner = 1 medial and 1 lateral (naked); coxal plate similar to first with 1 anterior and 3 posterior setae. *Pereopods* (Fig. 4): coxa 3 with setae similar to coxa 1, arranged 1 anterior, 1 posterior; coxa 4 similar, both setae anterior; pereopods 3-4 longer than gnathopod 2; pereopods 3-5 approximately equal, articles 4,5 sparsely setose posteriorly, the posterior margin of article-6 (pereopod 3 only) with armament formula = ---1--1, thus with only one locking spine; pereopods 5-7 similar but consecutively elongate, with 1,2,1 locking spines; pereopod 7 anterior spines of articles 5 and 6 displaced inward by keel-like expansion of the segment; coxae 5-7 bearing 0,0,1 setae on posterior lobes, article-2 weakly expanded progressively from pereopods 5-7, not lobate, but extended posteriorly and bearing few setae on pereopod 5, becoming increasingly robust in pereopods 6 and 7; dactyls of pereopods 3-7 simple, naked except for an anterior basal penicillate setule, with the addition of an outer terminal setule on pereopod 7. *Gills*: coxae 2-6 with flask shaped gills, gill of coxa 3 largest, of coxae 5-6 slightly reduced. *Pleopods* (Fig. 5): retinaculæ 2 per pleopod, one accessory each; peduncles 1 and 3 with an apicolateral seta, 2 without; rami extending subequally, the inner with 5:5:5 articles, the outer with 6:6:5; no bifid setae on basal articles. *Epimera* (Fig. 5): epimera posteroventrally quadrate; posterior margins scarcely convex on 1-2, concave on epimeron 3, all smooth, with few or no setae; epimera 2-3 with 2 and 1 weak ventral spines, lacking lateral oblique ridge. *Pleon* (Fig. 5): pleonites 1-4 with dorsolateral posterior setae; pleonite 6 with 1 dorsolateral and 1 distoventral spinule. *Uropods* (Fig. 5): uropod lengths relative to uropod 1 are uropod 2 =  $0.6 \times$ , uropod 3 =  $1.5 \times$ ; uropod 1 peduncle length  $1.3 \times$  inner ramus, the outer margin bearing a single apicodistal spine and reduced row of 2 mid-dorsal spines, the medial apex bearing 2 spines; rami of subequal length (inner : outer = 62:54), both naked except for a single mid-dorsal spine on the inner ramus; both rami with 5 terminal spines; uropod 2 peduncle length  $0.9 \times$  inner ramus, bearing a single apicolateral spine only; inner ramus length  $1.4 \times$  outer, the medial margin bearing 2 spines only, 5 terminal spines; outer ramus shorter, devoid of any but 5 terminal spines; uropod 3 strongly extended beyond uropods 1-2 in entire animal; peduncle length  $0.14 \times$  outer ramus, shorter than urosomite 3 (25:50), bearing single mid-dorsal and laterodistal marginal setae, 1 subapical lateral seta, and 1 small mid-medial submarginal, facial seta; outer ramus proximal article

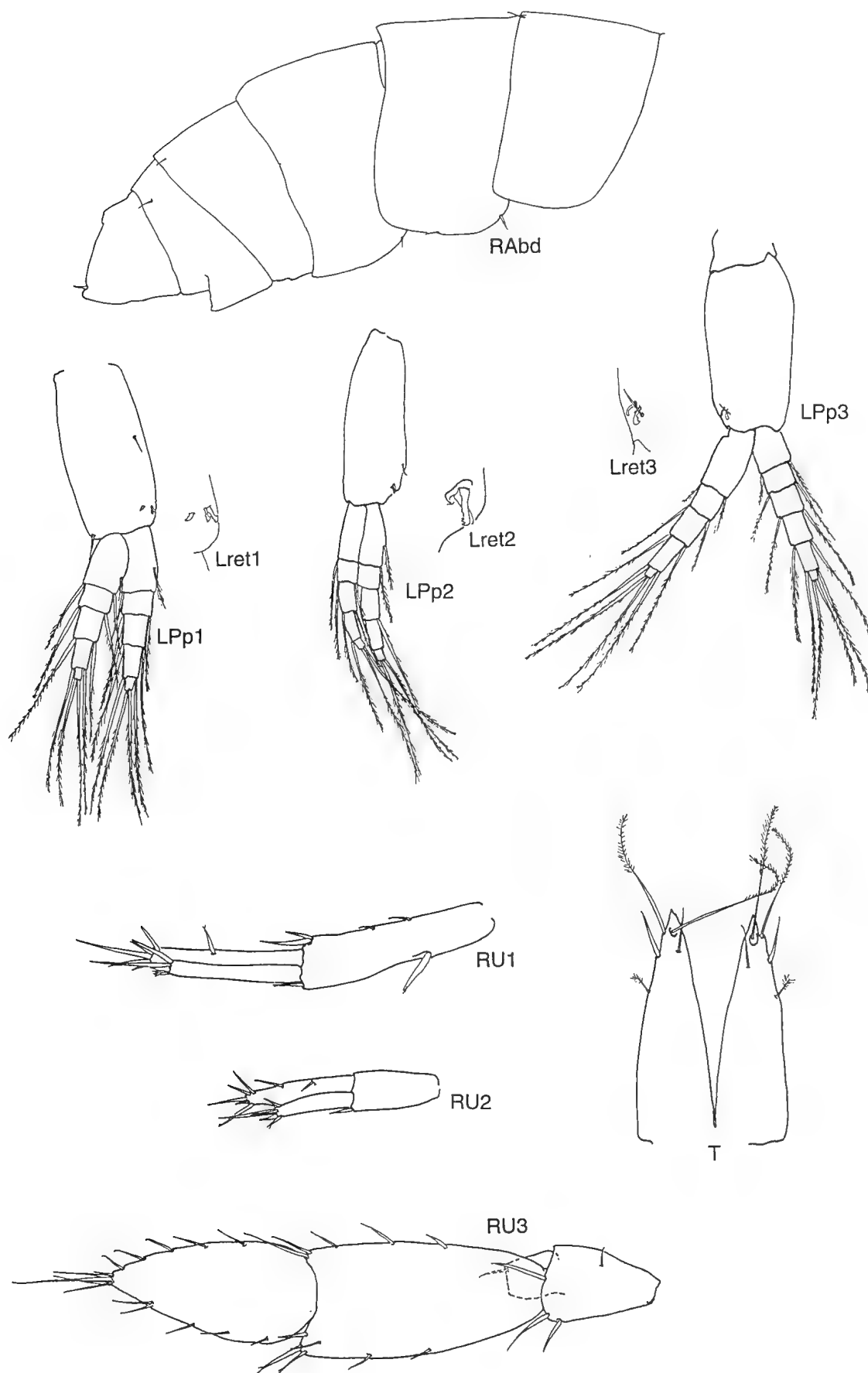


Fig. 5. *Nedsia straskraba* holotype male "a" 2.7 mm. Abdomen, pleopods, uropods, telson.

with few marginal setae, 2 apicomedial setae, 3 apicolateral setae and 1 subapical submarginal lateral seta, article-2 shorter (80:100), similarly armed, terminating in a cluster of 5 spines; inner ramus scale like, subquadrate, length  $0.13\times$  outer, bearing a single apicomedial spine. *Telson* (Fig. 5): length  $1.5\times$  width, widest at base, subequal in length to urosomite 3 (45:50), cleft 100%; apices slightly notched laterally female), apex of right lobe notched minutely medially; subapices with 2 long plumose setae, 1 submarginal medial seta and 1 lateral seta at M0.8, no other dorsal setae except for single penicillate setules on both lobes laterally at M0.7.

**Description of other material.** Specimen "b", male, length 2.5 mm. *Pleonite 6* with a single dorsolateral spine. *First antenna*: flagellum of 20 articles, aesthetascs present on articles 8,9,10,12,13,14,16. *Mandibles*: ratio of length of palp articles 1-2 = 15:12; setae of terminal article = 2E; interraker plumose setae present between accessory blades. *Left mandible*: palp article-2 shorter than in type; 15:12, setae = 2E; distal plumose seta present on both molars. *Maxillae*: spines of palp of left first maxilla not plumose *Maxilliped*: palp article-3 with rows of setae basal to dactyl; nail of dactyl short. *First gnathopod*: coxal plate without posteroventral seta. *Pleopods*: accessory spines adjacent to retinaculae = 1,0,0. accessory spine present adjacent to retinacula of pleopod 1 only. *Uropod*: lengths relative to uropod 1; uropod 2  $0.7\times$ , uropod 3  $2\times$ ; peduncle of uropod 1  $1.9\times$  length of inner ramus, of uropod 2 equal to ramus; uropod 2 inner ramus  $1.3\times$  outer; peduncle of uropod 3  $0.27\times$  length of outer ramus (longer than in type;  $0.14\times$ ), second article of outer ramus relatively longer than in type (90:102).

**Relationship.** *Nedsia straskraba* varies from *N. douglasi* in that pleonites lack dorsal spines, the second peduncular article of the first antenna is relatively shorter, the mandibular palp is similar being 2-articulate, with reduced terminal setation, the inner plate of the second maxilla has fewer medial setae, coxae 1-2 are longer than broad versus broader than long, the palmar spines of the first gnathopod are apically dentate, not asymmetrically bifid, there are no setae along the palm and the inner edge is finely serrate, the second gnathopod is weakly enlarged, melitid, the carpus less lobate, the palm more strongly oblique with few spines or setae and palmar corner poorly defined, the fifth and sixth coxal gills are reduced slightly compared with *N. douglasi*. The principle feature separating this species from all but *N. fragilis* and *N. humphreysi* is the absence of marginal pubescence on both plates of the second maxilla, and from *N. macrosculptilis*, *N. sculptilis*, *N. fragilis* and *N. humphreysi* the absence of dorsal spines or sculpturing of the pleon and of facial spines on the epimera. *Nedsia straskraba* is unlike *N. fragilis* in that the palmar corner of the gnathopod 1 is subquadrate and unlike *N. hurlberti* in lacking a spine-like extension of the first urosomite.

**Distribution.** Barrow Island, Western Australia.

### *Nedsia hurlberti* n.sp.

Figs 6-8

**Etymology.** Named for S.H. Hurlbert, noted biostatistician and salt lake limnologist.

**Type locality.** Western Australia, Barrow Island, Western Australian Museum, Western Australian Museum sample site BES545.

**Material examined.** HOLOTYPE (Western Australian Museum WAM 2-96) female 4.5 mm, unique specimen.

**Diagnosis.** *Pleonite 6*: small dorsal spines, displaced laterally. *First antenna*: ratio of peduncular articles 45:40:15. *Second antenna*: very short. *Upper lip*: symmetrical, not excavate. *Mandible*: palp 2-articulate, article-1 not setose, article-2 linear, setae = 2E; plumose interraker setae present between each main raker; no additional serrations beyond rakers. *Maxillae*: well setose medially. *First maxilla*: inner plate with 7 plumose medial setae; palps symmetric with 7 thin apical spines. *Second maxilla*: inner plate with a row of medial setae barely extending onto face apically, no other medial setae. *Maxilliped*: outer plate large, with 2 stout plumose setae distally and a single naked tooth-spine; paired submarginal medial setae of the outer plate blunt, apically curved; palp articles 2-3 with single lateral setae, article-3 naked basally, moderately setose distally, with rows of short setae adjacent the base of the dactyl, the apex not produced. *Coxae*: coxae 1-4 lacking posterior spines. *First gnathopod*: palm slightly oblique; palmar spines apically dentate. *Second gnathopod*: defining corner with 2 spines. *Epimera*: without setae, each with some facial spines adjacent ventral and posterior margins. *Pleopods*: peduncles of pleopods 1-2 without setae, of pleopod 3 with 2 lateral setae; basomedial setae of inner rami bifid, no accessory retinaculae. *Telson*: cleft 100%.

**Description of holotype (female).** *Body* 4.5 mm. *Head* (Fig. 6): rostrum obsolescent; eyes absent. *First antenna* (Fig. 6): length  $0.5\times$  body (broken at article-17), longer than antenna-2, flagellum much longer than peduncle; peduncle article-1 longest, 3 shortest, setae sparse; flagellum of many articles (17+), without calceoli or aesthetascs; accessory flagellum of 2 articles, article-2 tiny, extending to M0.7 of article-1 of the primary flagellum; articles of primary flagellum variable in length. *Second antenna* (Fig. 6): short, length  $0.27\times$  body; peduncle very much longer than flagellum, articles 4-5 equally long, articles 3-5 with weak ventral setation of 0-2-7 naked setae and 1-2-1 plumose setae, article-3 without dorsomedial spines; flagellum 4-articulate, without calceoli. *Upper lip* (Fig. 6): without excavation of the apical margin, connection to the epistome symmetrical. *Left mandible* (Fig. 6): palp article-1 shorter than 2 (11:35), setae



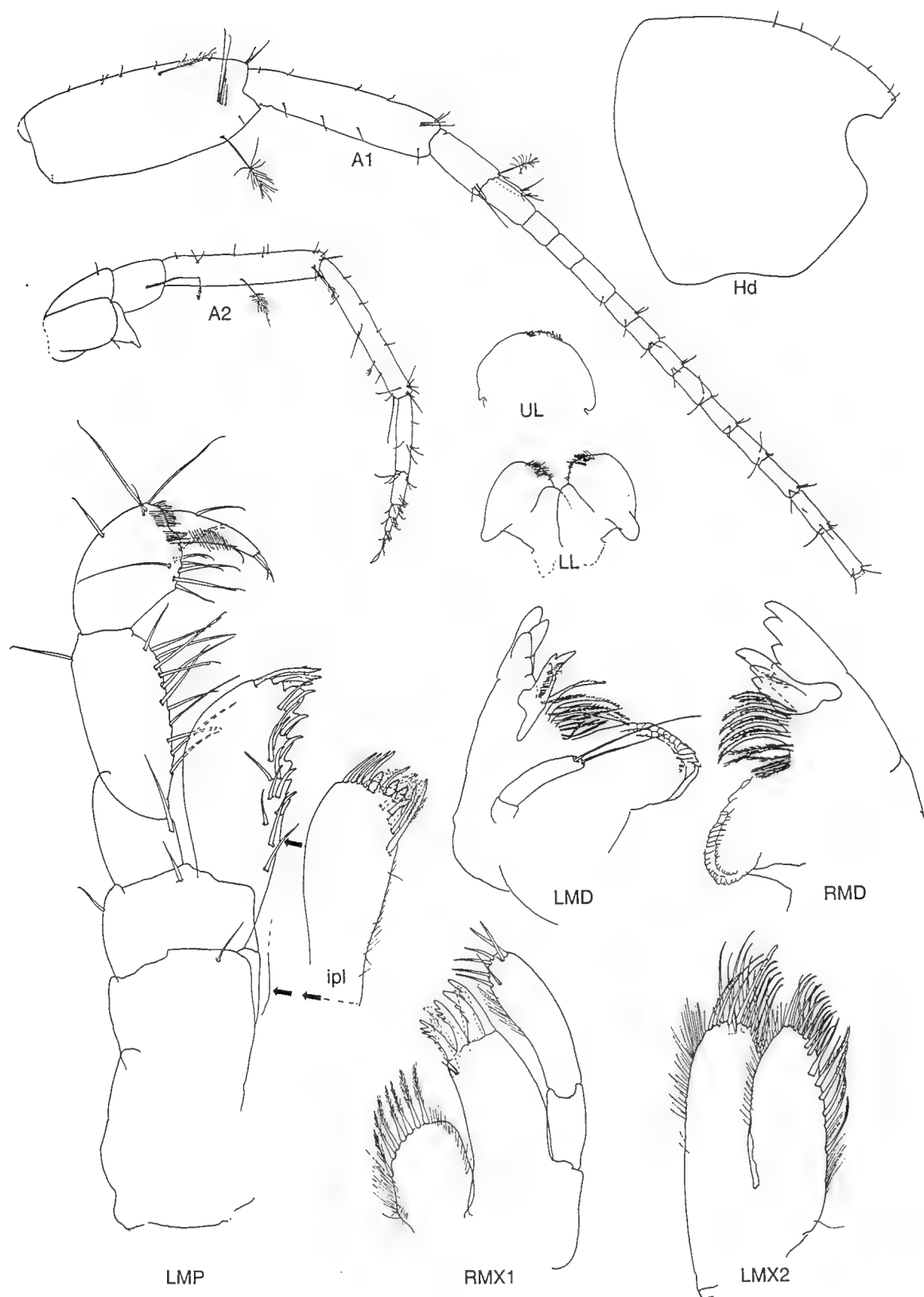


Fig. 6. *Nedsia hurlberti* holotype female 4.5 mm. Head, antennae, mouthparts.

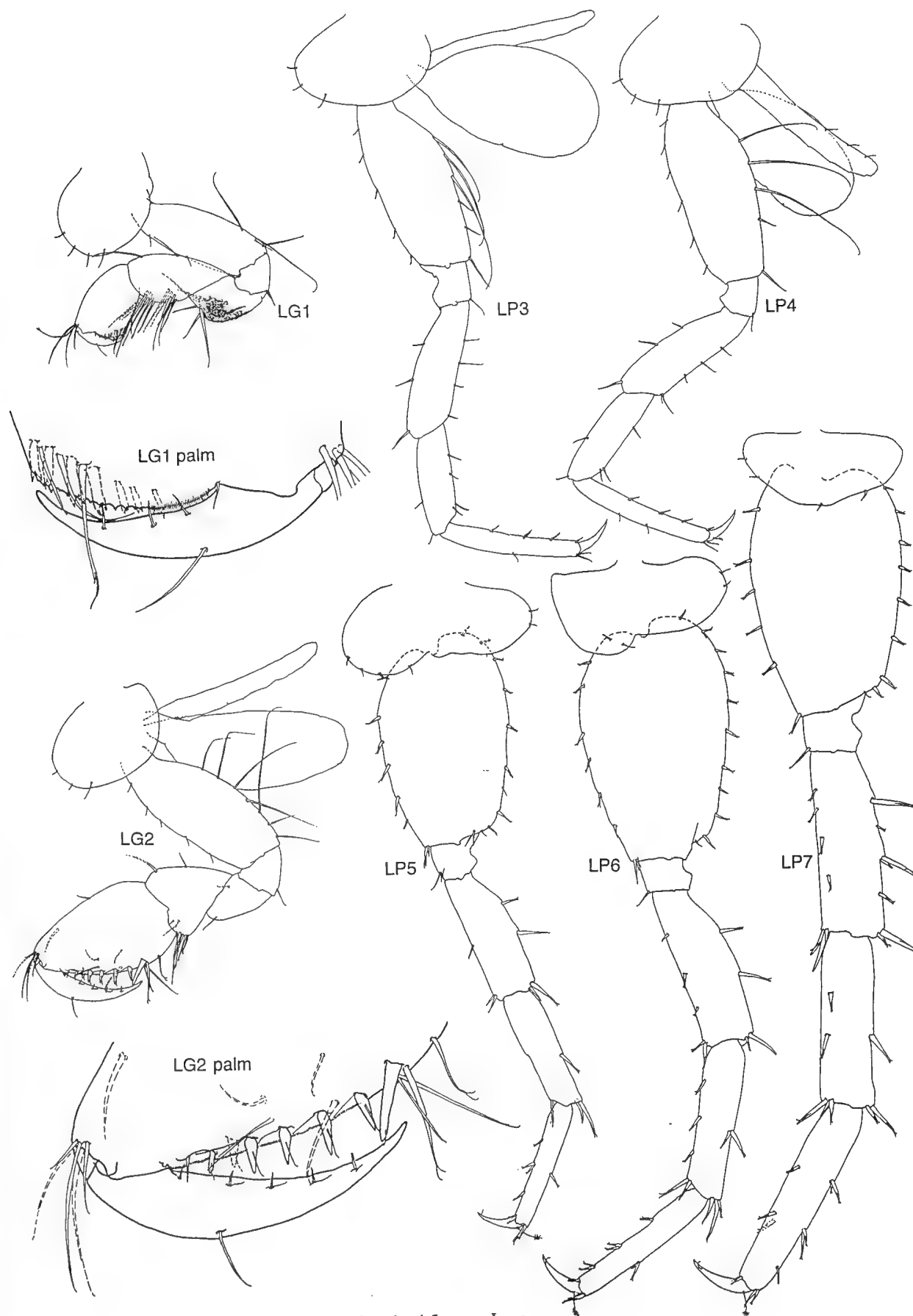


Fig. 7. *Nedsia hurlberti* holotype female 4.5 mm. Legs.

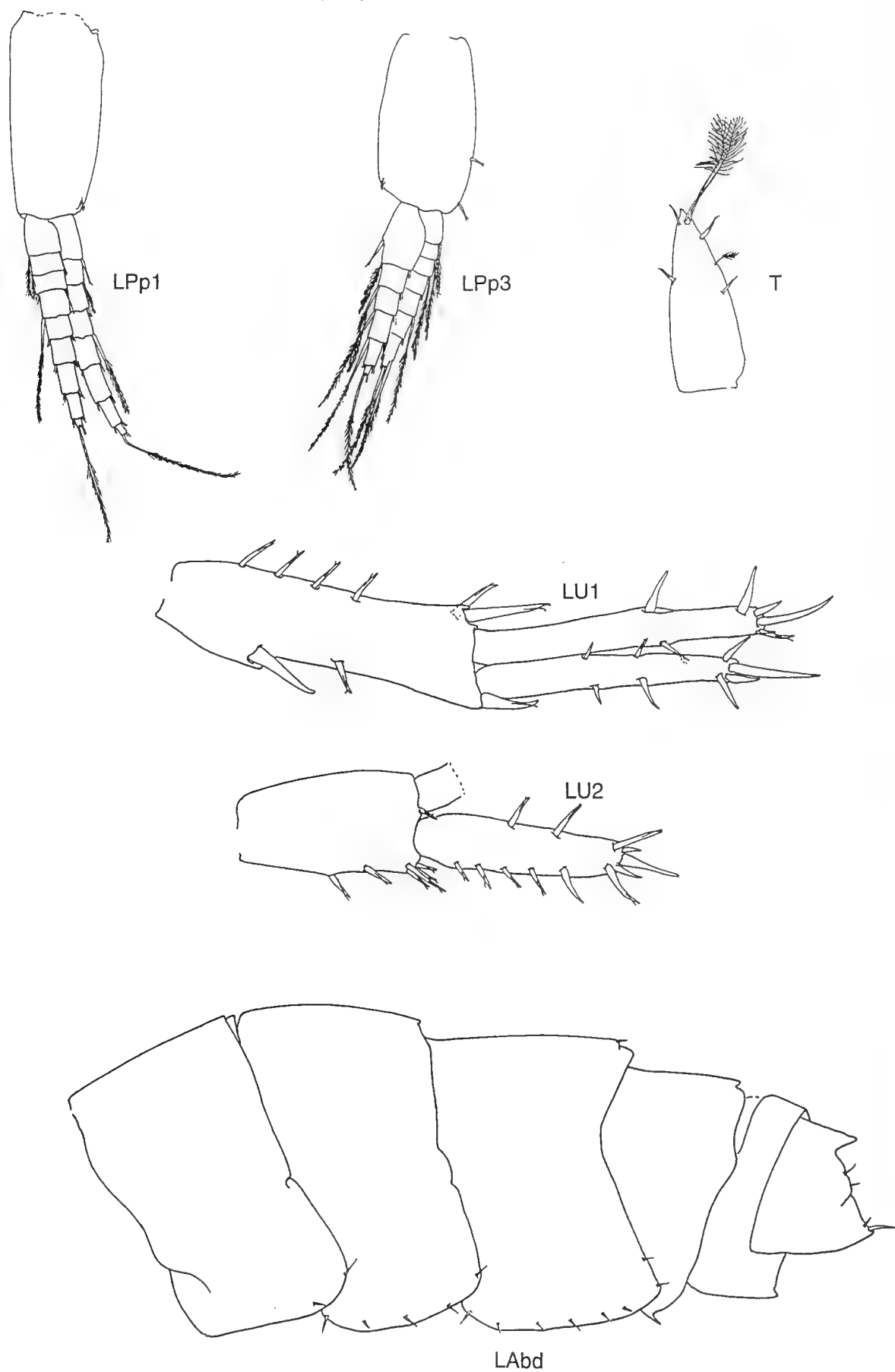


Fig. 8. *Nedsia hurlberti* holotype female 4.5 mm. Abdomen, pleopods, uropods, telson.

of article-2 = 2E: incisor 4 toothed; 4 setose accessory blades; lacinia mobilis bearing a row of short facial setae; plumose setae lying between each raker extend to the base of the molar; molar lacking distal plumose seta, without pubescence. *Right mandible*: incisor 5 toothed; lacinia mobilis 4 toothed and bearing facial setae; accessory blades of 5 plumose spines. *Maxillae* (Fig. 6): *first maxilla* palps of both sides bearing 7 thin apical and subapical spines; outer plate with 7 denticulate spines, the inner plate 7 medial setae; second maxilla, medial and apicomedial margin of both plates pubescent as is basomedial margin of inner plate. *Maxilliped* (Fig. 6): palp article-3 with moderate setae on the inner edge, dactyl bearing a row of mid-facial setae and terminal accessory spine slightly longer than the nail. *First gnathopod* (Fig. 7): coxal plate bearing 4 short setae apically, without posteroventral spines; article-4 posteriorly bulbous and facially pubescent; carpus not lobate; propodus trapezoidal, expanding slightly apically, longer than wide, the posterior edge naked, corner of the palm almost square marked laterally by 2 moderate unarmed spines and 1 long trigger spine, and medially by 4 stout trigger spines, palm convex, dactylus reaching the palmar corner, bearing 3 small spines submarginal to the inner edge. *Second gnathopod* (Fig. 7): coxal plate broader than coxa 1, poorly setose, with 3 anterior setae; propodus 2× that of gnathopod 1, palm bearing 5 lateral trigger spines, single unarmed distal spine, single medial trigger spine at M0.5 and a single long seta at M0.2 from the palmar corner; the palmar edge is finely serrated, the corner defined by a single long slender trigger spine, 1 long, stout trigger spine and 2 long setae. *Pereopods* (Fig. 7): coxa 3 slightly larger than coxa 2, coxa 4 more irregular, both with similar setae = 3 anterior, none posterior, coxae 5–7 with few setae on the ventral margin of posterior lobes (0–0.2); pereopods 3–7 longer than gnathopod 2, progressively elongate; pereopods 3–4 posterior armament formula of article-6 = S-S-S-S and S-2S-S-S, thus both with a single locking spine; pereopods 5–7 each with 2 locking spines; article-6 of pereopod 7 without posterior keel like expansion; article-2 of pereopods 5–7 expanded, but not posteroventrally lobate, bearing small trigger spines; pereopods 3–7 dactyls simple, naked, with an outer basal penicillate setule and a short subterminal seta. *Gills*: flask shaped gills on coxae 2–6; gill of coxa 6 not reduced. *Oostegites*: thin, strap like and poorly setose, present on coxae 2–5. *Pleopods* (Fig. 8): 2 retinaculæ per pleopod, without accessory retinaculæ, peduncle 3 only bearing a single apicolateral seta, rami extending subequally, the inner rami bearing 9–9–8 articles, the outer 9–9–6; basal article setae of rami 1–2 = 1–1–1–1, of which the inner seta is bifid on each. *Epimera* (Fig. 8): epimera 1–2 posteroventrally curved; epimeron 3 subquadrate, the posteroventral corners with 1–1–2 setae; posterior margins smooth, barely setulose, ventrofacial spines present as 1–4–6. *Pleon* (Fig. 8): pleonite 3 with a tiny posterior dorsal seta, pleonite

6 with 2 distolateral and 2 distoventral spines; uropod 3 strongly extended beyond uropods 1–2 in entire animal. *Uropod*: lengths relative to uropod 1 = uropod 2 0.6×, (uropod 3 1.3×). *Urosome* (Fig. 8): ventrodiscal spine at base of uropod 1 on urosomite 1 absent, although urosomite 1 extended ventrodistally in a spine like projection. *Uropods* (Fig. 8): uropod 1 peduncle length equal to medial ramus, the outer margin bearing a single apicodistal spine and row of 4 dorsal spines, the medial margin 2 apical spines; rami subequal, both with 2 sparse rows of marginal spines, spines of the apex = 4 and 5; uropod 2 peduncle 0.9× length of outer ramus, bearing, as well as 2 apicolateral spines, single lateral and dorsal subapical spines, 1 dorsolateral spine at M0.7, 1 lateral spine at M0.5 and 1 mid-apical dorsal spine; no apical spines of the medial margin; (outer ramus shorter than inner) (both) with 2 rows of marginal spines of the form 5–1, (1–3), spines of the apex = (4)–5; uropod 3 (lost; similar to others of genus i.e. peduncle much shorter than outer ramus, shorter than urosomite 3, with subdistal seta, an apicolateral cluster of 5 spines, the outer ramus proximal article with several irregular spine/seta ranks, article-2 shorter but similarly armed; inner ramus much shorter than outer (0.4×) with a single apical spine). *Telson* (Fig. 8): 1.3× longer than broad, shorter than urosomite 3 (0.75×); cleft 100% of length; apices barely notched, 2 long penicillate setules and 1 shorter naked seta subapically, dorsal setae at M0.5 and M0.8, single medial seta at M0.6, and a single penicillate setule dorsolateral at M0.6.

**Relationship.** *Nedsia hurlberti* varies from *N. douglasi* in the shorter relative length of the first antenna and the variable length of the articles of the primary flagellum, no excavation or asymmetry of the upper lip, reduced dentition of the left mandibular incisor, inner plate of the first maxilla with an extra seta, the inner plate of the second maxilla apically pubescent, palp and dactyl of maxilliped more spinose, as are the propodus and dactyl of the gnathopods, absence of a posterior keel like extension of the sixth article of the seventh pereopod, the posterior margins of the epimera sinuous and epimeron 2 bearing an additional ventral seta, pleopods bearing an accessory retinaculum, the telson longer and more slender. *Nedsia hurlberti* differs from *N. straskraba*, *N. fragilis* and *N. humphreysi* in that the margins of both plates of the second maxilla bear pubescence, from *N. macrosculptilis* and *N. sculptilis* in that the pleon is not sculpted, nor the epimera bearing facial spines, and from *N. urifimbriata* in the presence of few ventrofacial spines on the second and third epimera, a spine like extension of the first urosome at the base of the first uropod, less than six articles of the pleopodal rami, and in the absence of organised comb rows of setae at the base of the dactylus of the maxillipedal palp.

**Distribution.** Barrow Island, Western Australia.

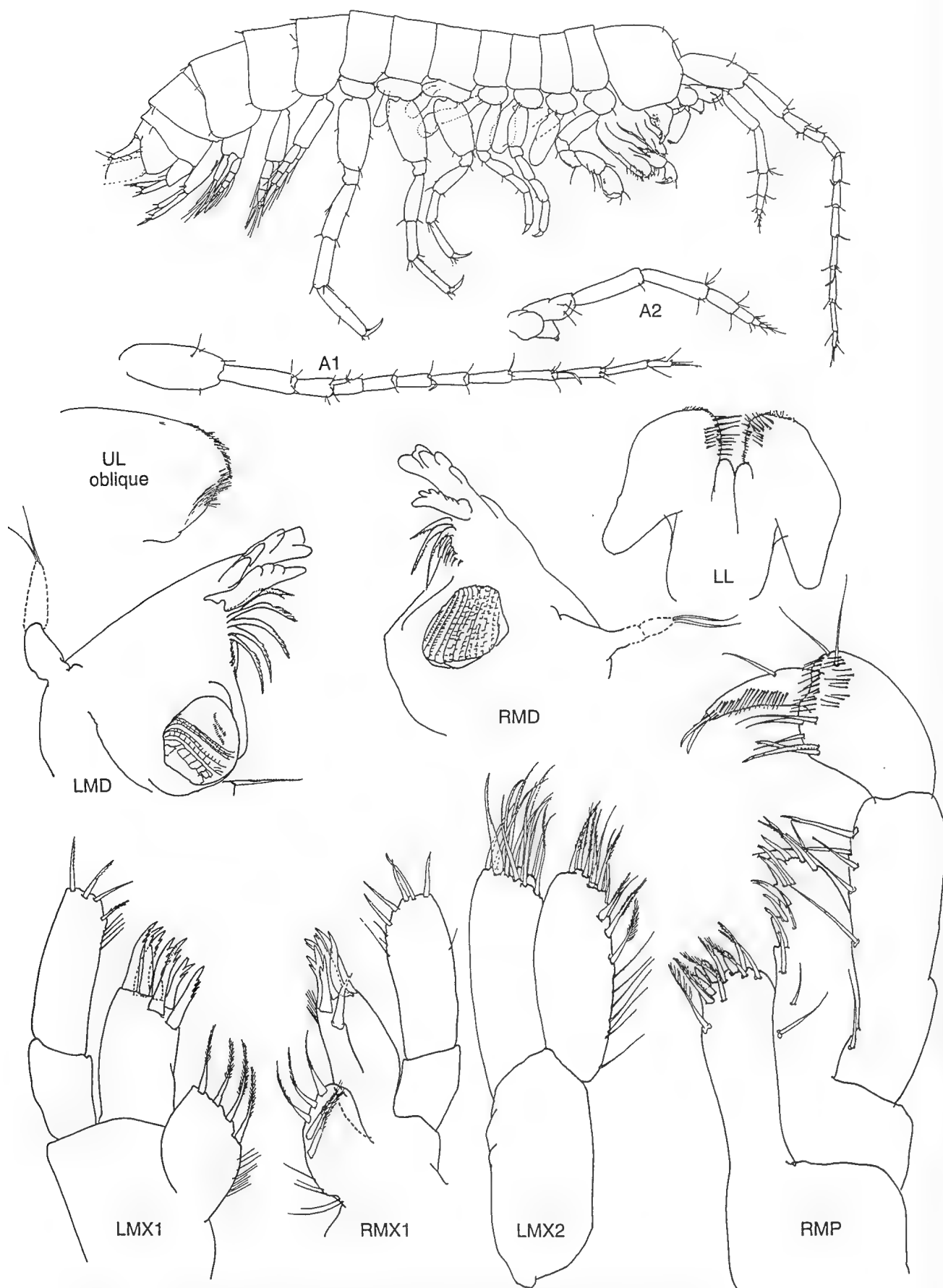


Fig. 9. *Nedsia humphreysi* holotype male 2 mm. Body, antennae, mouthparts.

*Nedsia humphreysi* n.sp.

Figs 9, 10

**Etymology.** Named for W.F. Humphreys, biologist, instrumental in the collection of Western Australian cave specimens.

**Type locality.** Barrow Island, Western Australia, Western Australian Museum sampling site BES710.

**Material examined.** HOLOTYPE (Western Australian Museum WAM 3-96) male 2 mm.

**Diagnosis.** Dorsal spines absent from pleonites 4–6. *Head:* lateral cephalic lobes slightly projecting. *Upper lip:* symmetrical, slightly excavate below. *Mandibular palp:* 2-articulate, 2E-setae only; lacking interraker plumose setae. *Maxillae:* without pubescence, sparse to moderately setose medially. *First maxilla:* palps asymmetric with thin apical plumose or serrate spines. *Second maxilla:* medial margins sparsely setulate, without pubescence. *Maxilliped:* apex of third article of palp slightly produced, dactyls with moderate nail and accessory spine of almost equal length. *Gnathopods:* (diverse, gnathopod 2 dominant); gnathopod 1 palmar spines bifid, spines at corner of palm submarginal = 2 lateral, 3 medial; palmar margin serrate, with submarginal row of fine setae. *Pereopods:* pereopods 3–4 lacking posterior spine sets on article-6. *Coxal gills:* gills 5–6 smaller but not substantially reduced. Sternal gills absent. *Epimera:* epimera 1–2 with 1, epimeron 3 with 2, posterior spines at the corner, ventrofacial spines absent. *Pleopods:* peduncles without setae, retinaculæ = 2-3-2, accessory retinaculæ absent. *Uropods:* apicolateral corner of peduncles on uropods 1–2 without spines, dorsal margins spineless, medial margins of both with 1 apical spine; rami of uropods 1–2 without spine rows except for inner ramus of uropod 1. *Telson:* cleft 100%; lobes with a small mid-lateral concavity.

**Description of holotype, (male).** *Body* (Fig. 9) 2 mm. *Head:* rostrum obsolescent; eyes absent. *First antenna* (Fig. 9): length 0.6× body, 2× antenna-2, flagellum 1.6× peduncle, peduncular article-1 longest without mediodistal spines or setae, article-3 shortest, setae sparse, flagellum of 9 articles, sparsely setulate, no aesthetascs or calceoli; accessory flagellum 2-articulate, article-2 tiny, total length 0.6× article-1 of the primary flagellum; length of articles of primary flagellum variable, article-7 longest. *Second antenna* (Fig. 9): length 0.3× body, peduncle longer than (3×) flagellum, articles 4–5 equally long, articles 3–4–5 with sparse ventral setation, article-3 with apicodorsal setae, no dorsomedial spines. Flagellum 4-articulate, no calceoli. *Upper lip* (Fig. 9): apical margin rounded, symmetrical. *Mandibles* (Fig. 9): left mandibular palp (2-articulate), article-1 very reduced, bud like, naked; incisor 5 toothed; lacinia mobilis with 4 teeth and 6 setose accessory blades; molar tritulative with a

short distal plumose seta, lacking other setae or pubescence; right mandible palp 2-articulate, article-1 naked, short, bud-like, article-2 reduced, tapered, 2E-setae only; incisor with 5 teeth; lacinia mobilis with 7 denticles their size increasing distally; accessory blades of 3 plumose spines; a line of setae extending onto the base of the molar. *Maxillae* (Fig. 9): *first maxilla*, left palp 2nd article with 5 serrate apical spines, terminally rounded with 3 small to moderate apicomедial setae; right palp article-2 with 4 plumose apical spines, terminally subquadrate, 4 apicomедial setae; outer plate of both sides with 7 terminal spines, some of the left without denticles; left inner plate with 4 apicomедial and apical plumose setae, moderately setose basally; right inner plate with 4 apicomедial and apical plumose setae, moderately setose medially. *Second maxilla*, inner and outer plates devoid of pubescence. *Maxilliped* (Fig. 9): palp article-3 with apical pair of slender setae, 1 marginal, 1 submarginal; medial face with 5 slender setae, the basal pair denticulate. Inner plate without ventrofacial spine. *First gnathopod* (Fig. 10): coxal plate with 1 short seta apically, without posteroventral spines; article-4 posteriorly bulbous, carpus not lobate, propodus trapezoidal, expanding apically, longer than wide, posterior edge almost naked, corner of palm almost square, with 2 lateral and 3 medial spines and several lateral and medial setae set back from the corner; palm convex and serrate; dactylus reaching slightly beyond the corner of the palm. *Second gnathopod* (Fig. 10): coxal plate equal to coxa 1, with a single ventral spine. *Pereopods* (Fig. 10): coxa 3 with 1 anterior and 1 posterior ventral setae only; coxa 4 similar; pereopods 3–4–5 longer than gnathopod 1; pereopods consecutively elongate from pereopods 3–7; ratio of lengths = 137:–140:155:185:220:270; all pereopods sparsely setose, posterior armaments of article-6 of pereopods 3–4 = 1–0, thus only pereopod 3 with 1 locking spine; pereopods 5–7 significantly longer than pereopods 3–4 with locking spines; 1,2,2; single anterior spines on article 6 of pereopods 6–7, one posterior spine on pereopod 7 only; no keel like expansion of article 6 of pereopod 7; coxae 5 and 7 bearing 1 anterior and 1 posteroventral seta and coxa 6 one anterior seta only; article-2 of pereopods 5–7 weakly expanded posteriorly, each with only 2 setae; dactyls of pereopods 3–7 simple, naked except for outer basal penicillate setule evident on pereopods 4–7 only. *Gills:* of coxae 2–6 flask shaped, of coxae 5–6, smaller, but not reduced. *Pleopods* (Fig. 10): retinaculæ present on each pair, arranged 2-3-2, accessory retinaculæ absent; peduncles without setae; rami extending equally, outer rami of 4-4-3 articles, inner 4-3-5. No setae bifid. *Epimera* (Fig. 10): each posteroventrally rounded, posterior margins slightly convex, smooth, without setae except for a single seta marking the posterior corner of epimera 1–2 and two on epimeron 3; ventrofacial spines absent; lacking oblique lateral ridge. *Pleon* (Fig. 10): pleonites with few posterior dorsal or lateral setae; pleonite 1 with 1 dorsal, 2 lateral; pleonite 2 with 1 submarginal and 1 marginal dorsal; pleonite 3 with 2 lateral; pleonites 4 and 5 with 1 lateral; pleonite 6 with

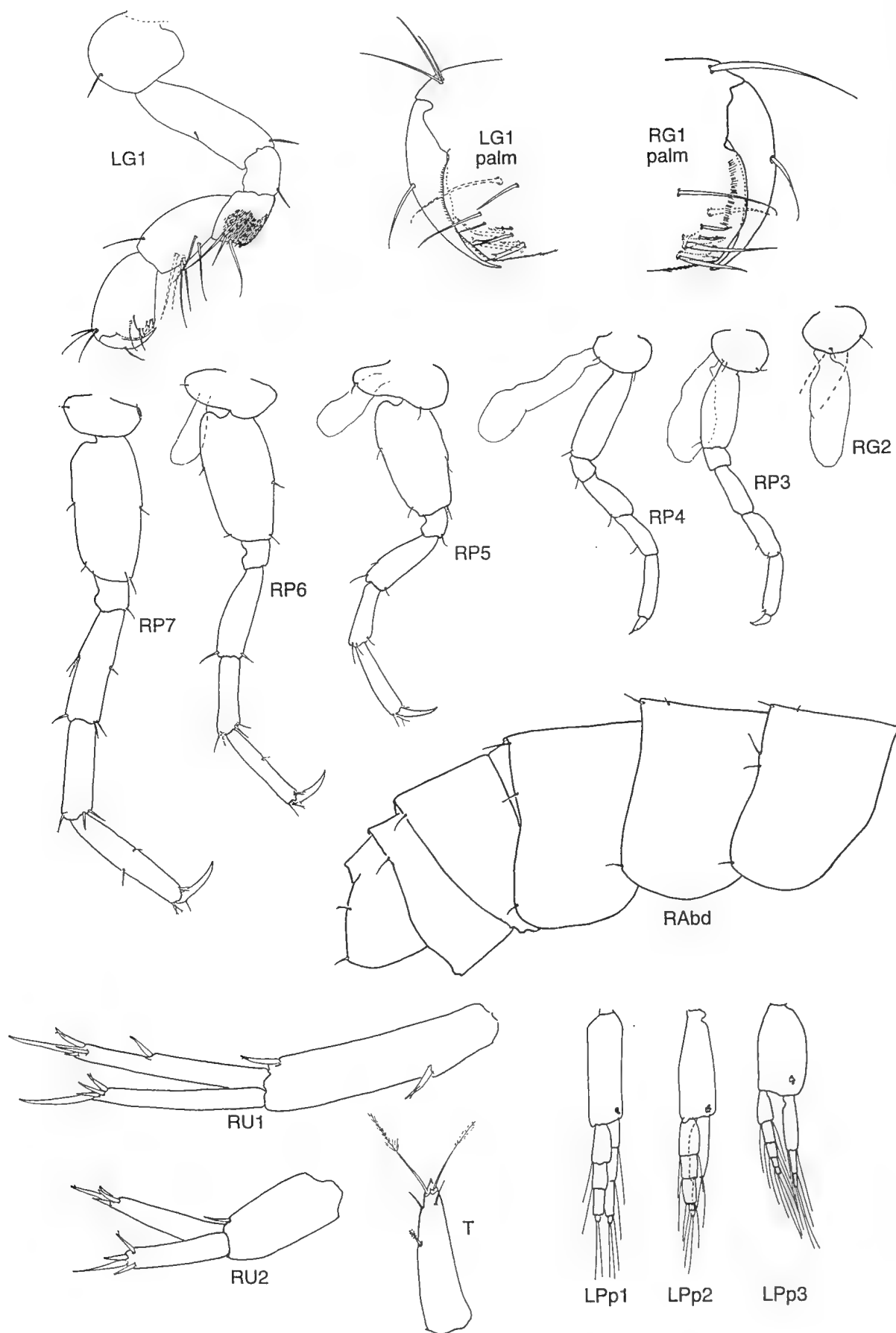


Fig. 10. *Nedsia humphreysi* holotype male 2 mm. Legs, abdomen, pleopods, uropods, telson.



1 mid-lateral and 1 distoventral seta. *Uropods* (Fig. 10): uropod 1 peduncle length  $1.4\times$  outer ramus,  $1.2\times$  inner ramus, apicodistal spines absent, bearing a single medial subapical spine, and basofacial spine at M0.3; inner ramus only with a mid-medial spine; both rami with 4 terminal spines; uropod 2 peduncle subequal to length of inner ramus, 1 apicodorsal spine slightly subdistal; other spines and setae absent; outer ramus shorter than inner ( $0.8\times$ ), both rami without spines, except 3–4 terminal spines. *Telson* (Fig. 10): longer than broad ( $1.8\times$ ), as long as urosomite 3; cleft 100%; apices pointed, not notched, each with 2 long plumose subapical setae, 2 apical setae, and a single lateral penicillate setule at M0.6.

**Relationship.** *Nedsia humphreysi* differs from *N. douglasi* in the reduced number of articles of variable lengths of the first antenna and relatively longer second antenna, a symmetrical and non-excavate upper lip, greater number of mandibular setose accessory blades and presence of a plumose molarial seta and basal molarial setae, palps of first maxilla asymmetrical, the inner plate with an extra seta, the second maxilla devoid of pubescence, the inner plate of the maxilliped without a ventrofacial spine, palmar corner of the first gnathopod with fewer armaments, the palm serrate and the dactyl reaching beyond the corner. The coxal plate of the second gnathopod is narrower, posteroventral margins of epimera rounded, epimera lacking ventrofacial spines, first uropod lacking apicodistal spines, second uropod peduncle less spinous, relatively shorter with only a single apicodorsal spine, the telson more slender, the apices pointed, not notched. *Nedsia humphreysi* is similar to *N. straskraba* and *N. fragilis*, but distinct from *N. hurlberti*, *N. urifimbriata*, *N. macrosculptilis* and *N. sculptilis*, in that marginal pubescence is not present on both plates of the second maxilla. *Nedsia humphreysi* differs from *N. straskraba* in that the pleonites bear dorsal spines, and from *N. fragilis* in that the first epimeron lacks distolateral spines, the peduncle of the first uropod is without a row of facial spines, the palmar corner of the first gnathopod is subquadrate rather than rounded, and the outer plate of the maxilliped is not tapering and is armed with distinct medial cusps.

**Distribution.** Barrow Island, Western Australia.

*Nedsia urifimbriata* n.sp.

Figs 11–13

**Etymology.** Named for the presence of marginal pubescence on the third uropod.

**Type locality.** Barrow Island, Western Australia. Western Australian Museum sampling site BES733.

**Material examined.** HOLOTYPE (Western Australian Museum WAM 4-96) male 2.5 mm. ALLOTYPE female 3 mm.

**Diagnosis.** *Mandibular palp*: 2-articulate, setae = 2E. *Second maxilla*: inner plate with submarginal mediobasal row of plumose setae barely extending onto the face apically, without medial setae, without pubescence. *Maxilliped*: inner plate with a reduced medial row of 1 faciobasal and 1 barely facial (submarginal) ventral seta; outer plate lacking a blunt naked tooth spine contiguous with distal plumose setae, an additional submarginal facial group of 4 setae at M0.3; palp article-3 with comb rows at the base of the dactyl, the apex weakly produced, dactylar nail moderately long, with a subequal accessory seta. *First gnathopod*: carpus equal to propodus in male, palmar spines symmetrically bifid. *Pereopods*: posterior spine sets of article-6 evenly spaced. *Pleopods*: peduncle 3 with 1 apicolateral seta, basomedial seta of inner rami not bifid; each with 2 retinaculae, no accessory retinaculum. *Epimera*: posteroventral tooth of epimera 1–3 present, posterior margins without setae, without facial spines. *Uropods*: uropods 1–2 apicolateral corners of peduncles with 2 and 1 spines, both rami of both uropods with only a single, poorly represented spine row; uropod 3 without subdistal peduncular setae. *Telson*: cleft 100%, lobes weakly convex laterally and medially; setation subapical, lacking lateral setal spines, single lateral penicillate setules at M0.3–0.5.

**Description of holotype (male “x”).** *Body* (Fig. 11) 2.5 mm. *Urosome*: poorly armed dorsally. *Head* (Fig. 11): rostrum obsolescent; eyes absent. *First antenna* (Fig. 11): elongate, longer than antenna-2, broken at article-6 of flagellum—broken length  $0.6\times$  body, (length  $> 2\times$  antenna-2); flagellum longer than peduncle, peduncular article-1 longest and bearing a strong mediobasal spine at M0.85, article-3 shortest, ratio of lengths 90:70:30, setae sparse; flagellum of many articles (broken at article-6), uniform, sparsely setulate; calceoli absent, no aesthetascs; accessory flagellum 2-articulate, reaching M0.5 article-1 of primary flagellum, second article tiny. *Second antenna* (Fig. 11): with weak ventral setation, article-3 without dorsomedial spines; flagellum 5-articulate, lacking calceoli. *Upper lip* (Fig. 11): (asymmetrical, weakly excavate below). *Left mandible* (Fig. 11): palp 2-articulate, article-1 shorter than 2 (35:47), article-2 bearing 2 apical E-setae; incisor 5 toothed, lacinia mobilis 5 toothed bearing on the medial face a row of short spines, 4 setose accessory blades and 3 inter-raker plumose setae; molar triturative, with a moderately long distal plumose seta. *Right mandible*: palp absent, incisor 5 toothed and lacinia mobilis 5 toothed with mediofacial spine row as on left side, 4 setose accessory blades and 2 inter-raker plumose setae; molar triturative, without distal plumose seta. *Maxillae* (Fig. 11): first maxilla palp article-2 bearing thin apical and subapical spines, configuration of the left side being; 4 naked, 1 denticulate, and 1 setate, the right side having one less naked spine, the outer plate of both sides with 7 denticulate spines; inner plate with 4 plumose mediobasal setae and 1 subdistal naked seta; second maxilla outer plate apicolateral margin pubescent, inner

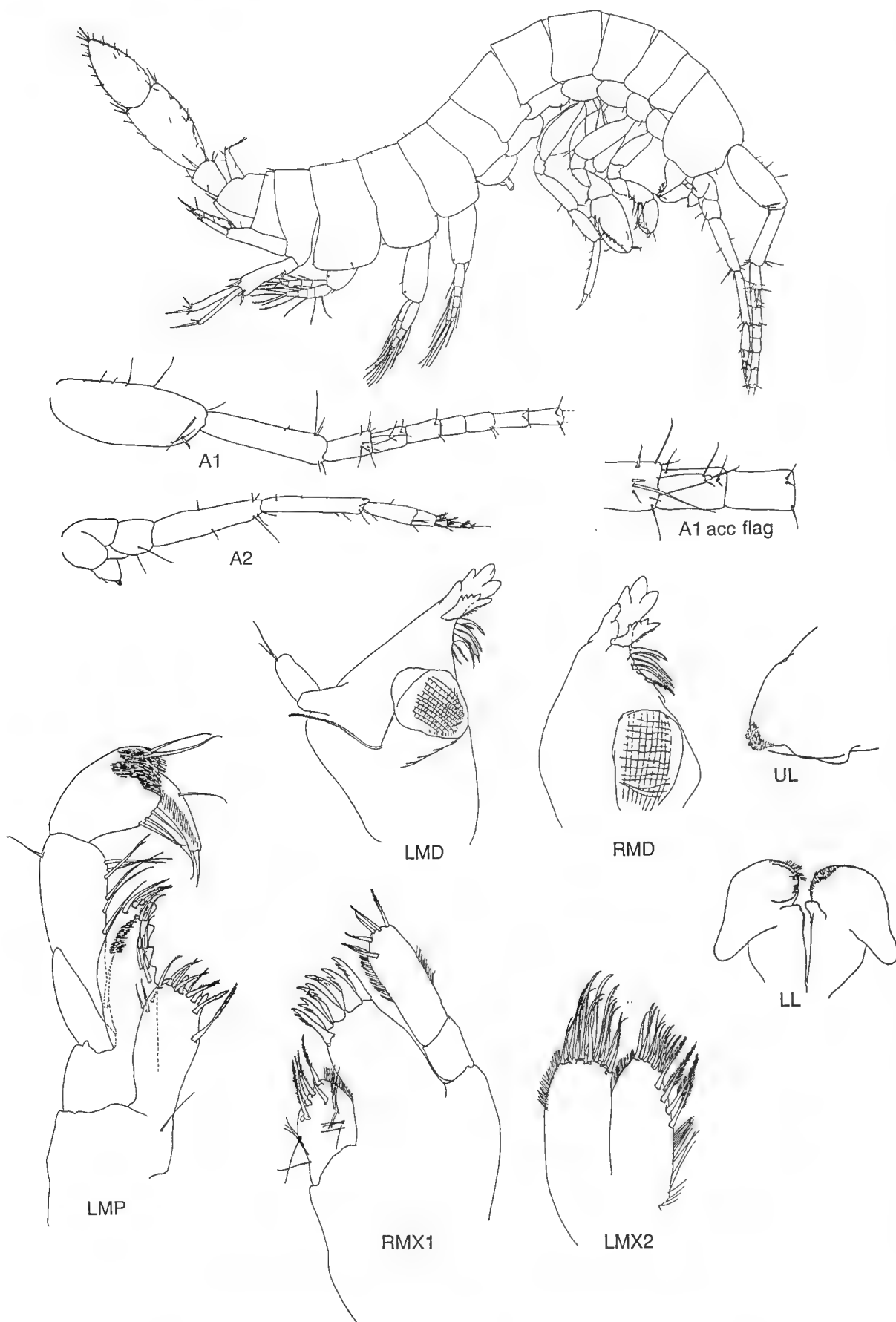


Fig. 11. *Nedsia urifimbriata* holotype male 2.5 mm. Body, antennae, mouthparts.

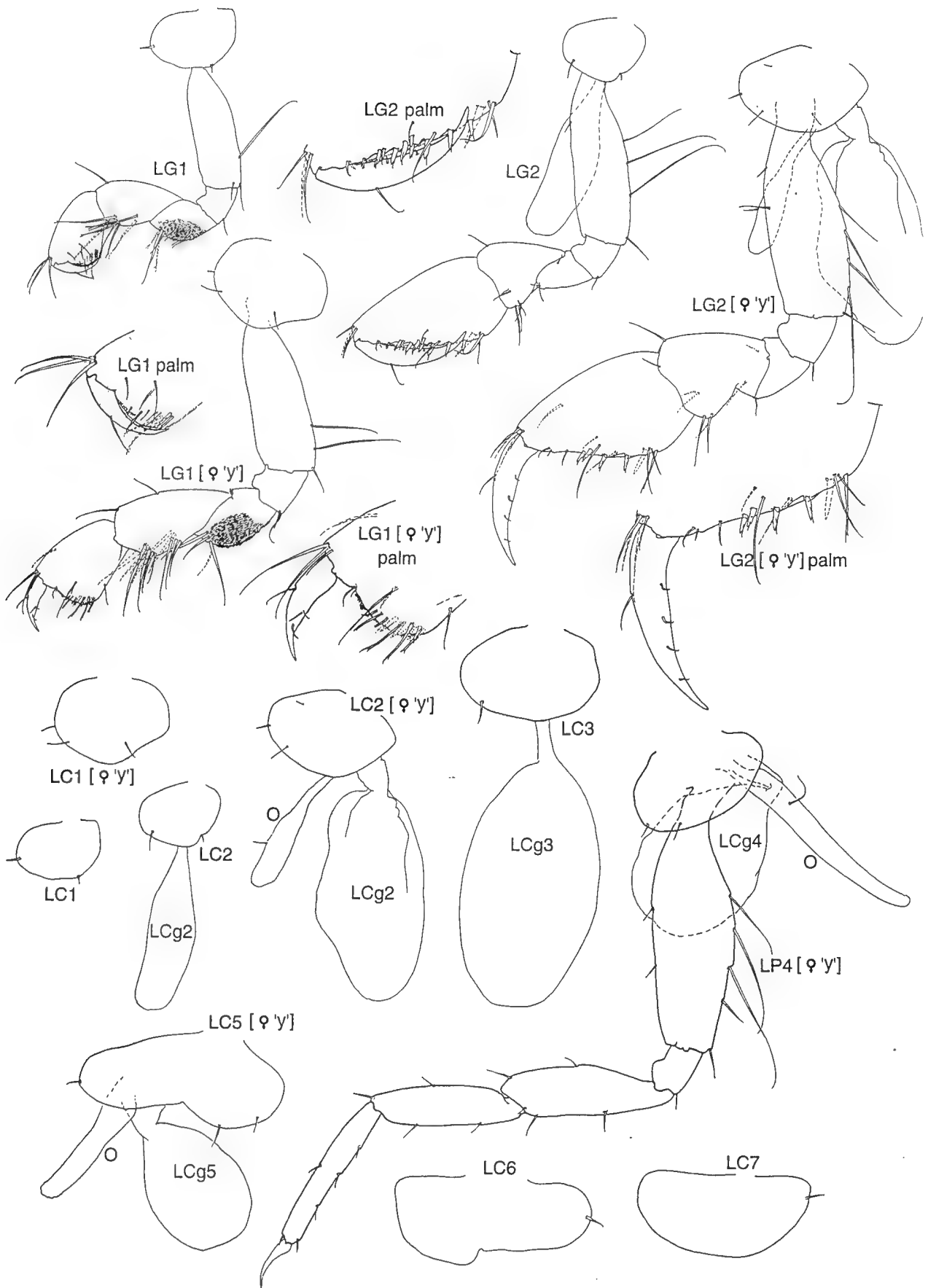


Fig. 12. *Nedsia urifimbriata* holotype male 2.5 mm: all drawings except those indicated as female "y". Legs.

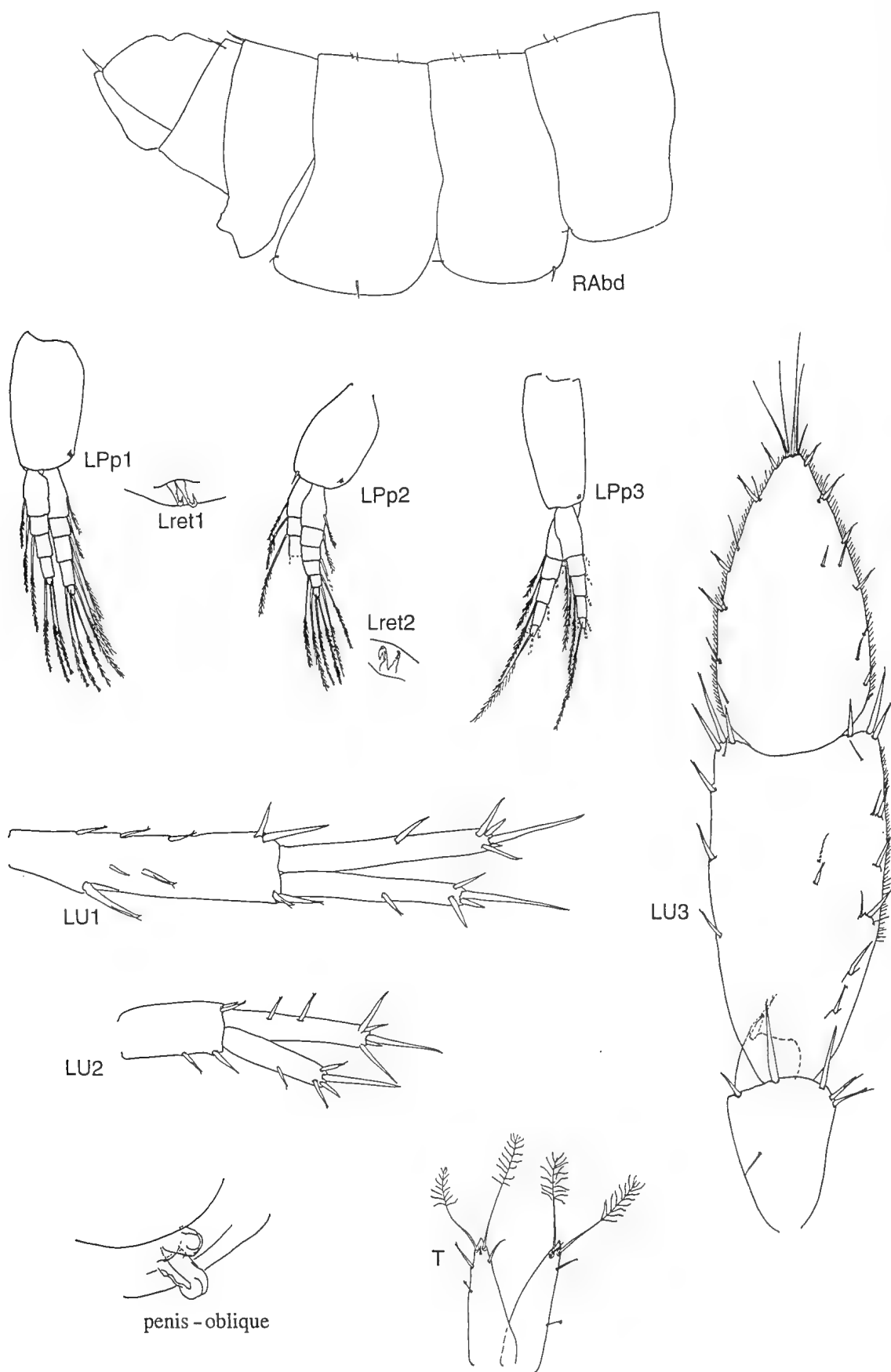


Fig. 13. *Nedsia urifimbriata* holotype male 2.5 mm. Abdomen, pleopods, uropods, telson, penis.

plate basomedial margin pubescent; apical spines of both plates mostly setate, but some naked. *Maxilliped* (Fig. 11): palp article-3 with 3 thin setae on the inner edge, no other facial setae; inner plate with a single mid-medial submarginal plumose spine. *First gnathopod* (Fig. 12): coxal plate bearing 1 or 2 short setae apically and 1 posteroventral spine; article-4 posteriorly bulbous and pubescent; carpus not lobate, propodus trapezoidal, expanding apically, length greater than width, the posterior edge naked; palmar corner rounded, marked by 2 lateral setae and 3 stout, bifid medial spines; palm convex, transverse, lined with fine setules; dactylus reaching slightly beyond the corner of the palm. *Second gnathopod* (Fig. 12): palm bearing 3 lateral and 6 medial spines, the spine at the palmar corner medial; coxal plate no broader than coxa 1, poorly setose. *Pereopods* (Fig. 12): coxa 3 bearing 1 anterior seta only, coxa 4 similar but with 1 small posterior seta; pereopods (3)–4 longer than gnathopod 2, pereopod (3) approximately equal to pereopod 4; articles 4–5 of pereopod 4 sparsely setulose posteriorly; posterior margin of article-6 of pereopods (3)–4 armament formula 1-1-1-1, i.e. with 1 locking spine; pereopods 5–7 absent; coxae 5–7 bearing few (1) setae on the ventral margin of posterior lobes; dactyls (3–7) simple as in pereopod 4, but without any basal penicillate setule. *Gills* (Fig. 12): coxal gills of limbs 2–4 flask shaped, none present on coxae 5–6(7); sternal gills absent. *Pleopods* (Fig. 13): peduncle of pleopod 3 only with an apicolateral seta; two retinaculae on each peduncle, without accessory spines; rami extending subequally, all with 5 articles; setae on basal articles = 3 for all rami, none bifid. *Epimera* (Fig. 13): epimera 1 and 3 posteriorly quadrate, epimeron 2 more rounded; posterior margins of epimera 1–2 weakly convex, of epimeron 3 linear; smooth, not setulose with no ventrofacial spines, lacking an oblique ridge. *Pleon* (Fig. 13): pleonites 4 and 5 with distolateral posterior seta, pleonite 6 with distoventral spine. *Uropods* (Fig. 13): uropod lengths relative to uropod 1 (300)—uropod 2 (165) = 0.55 $\times$ , uropod 3 (485) = 1.6 $\times$ ; uropod 1 peduncle length 1.3 $\times$  inner ramus, outer margin without an apicodistal spine, with 2 apicomедial and 2 apicolateral spines, bearing a short row of 2 dorsal and 3 medial spines; rami of subequal length (lateral : medial = 116:130), both rami bear a single mid-dorsal spine, medial ramus with 5 terminal spines, the lateral with 4; uropod 2 peduncle 0.7 $\times$  length of inner ramus, no apicodorsal spines, 1 mid-lateral spine, 1 sub-apicolateral spine, and 2 apicomедial spines; outer ramus shorter than inner (70:95), both with marginal spines; lateral ramus with 1 mid-lateral spine, medial ramus with 2 medial spines; apices of rami with 4 (lateral) and 5 (medial) terminal spines; uropod 3 peduncle length 0.24 $\times$  outer ramus, shorter than urosomite 3 (47:52), with no subdistal setae, an apicolateral group of 3 spines, single mid-distal spine, single apicomедial spine, and single small mid facial spine; outer ramus lateral margins of both articles and medial margin of distal article, bearing short, marginal pubescent fringe; proximal article with several irregular spine-seta ranks, these

submarginal laterally, a pair of mid-facial setae, sparse medial setae, 3 apicolateral and 3 apicomедial setae, terminal article shorter (190:200), similarly armed, distally with a group of 4 long and 2 short setae. *Telson* (Fig. 13): 1.5 $\times$  longer than broad, as long as urosomite 3, cleft 100%; apices minutely notched, subapices each with 2 long distal plumose setae, 2 or 3 distal and marginal setae, each lobe bearing a single penicillate setule at M0.3 or 0.5. Small penial processes borne on sternum of thoracic article-7 (Fig. 13).

**Description of allotype (female “y”).** *Body* 3 mm. *First gnathopod* (Fig. 12): coxa with 2 anterior setae, article-2 with 2 long posterior setal spines and 1 distal seta, merus with elongate seta of the pubescent posterior lobe and short setae anterodistally; carpus bearing 12 rather than 9 long spines, propodus and dactyl more spinous than male. *Second gnathopod* (Fig. 12): more setose and spinous than male; coxa without posterior seta, bearing 3 (rather than 1) anterior setae. *Oostegites* (Fig. 12): gnathopod 2–pereopod 5 each bearing a simple strap like oostegite with few setae or spines.

**Relationship.** *Nedsia urifimbriata* differs from *N. douglasi* in that the peduncle of the first antenna bears a strong mediiodistal spine, the second antenna is slightly longer, the molar is triturative with a moderately long distal plumose seta, the palps of the first maxilla are symmetrical, the maxillipedal palp bears an extra medial seta, the inner plate a single mid-medial, submarginal plumose spine, the first gnathopod bears fewer palmar spines, the dactyl reaches beyond the palmar corner, the palm of the second gnathopod bears more spines, apical setae of the peduncles of the pleopods are present on pleopod 3 only, the first uropod lacks an apicodistal spine, and the rami with single mid-dorsal spines each, the peduncle of the second uropod is relatively short, without apicodorsal spines, and the telson longer than wide, as long as urosomite 3. *Nedsia urifimbriata* differs from *N. straskraba*, *N. fragilis* and *N. humphreysi* in the presence of marginal pubescence on both pates of the second maxilla, from *N. hurlberti* in the presence of ventral submarginal spines on the second and third epimera, of organised comb rows of setae at the base of the maxillipedal dactyl, and of more than six flagellar articles on the pleopods, and in the absence of a spine like extension of the first urosome at the base of the first uropod. *Nedsia urifimbriata* differs from *N. macrosculptilis* and *N. sculptilis* in the presence of anterior spines, but absence of setae, on the first coxal plate, the absence of dorsal setae on the telson and of sculpturing of the pleon, and in possessing a long outer plate on the maxilliped.

**Distribution.** Barrow Island, Western Australia.

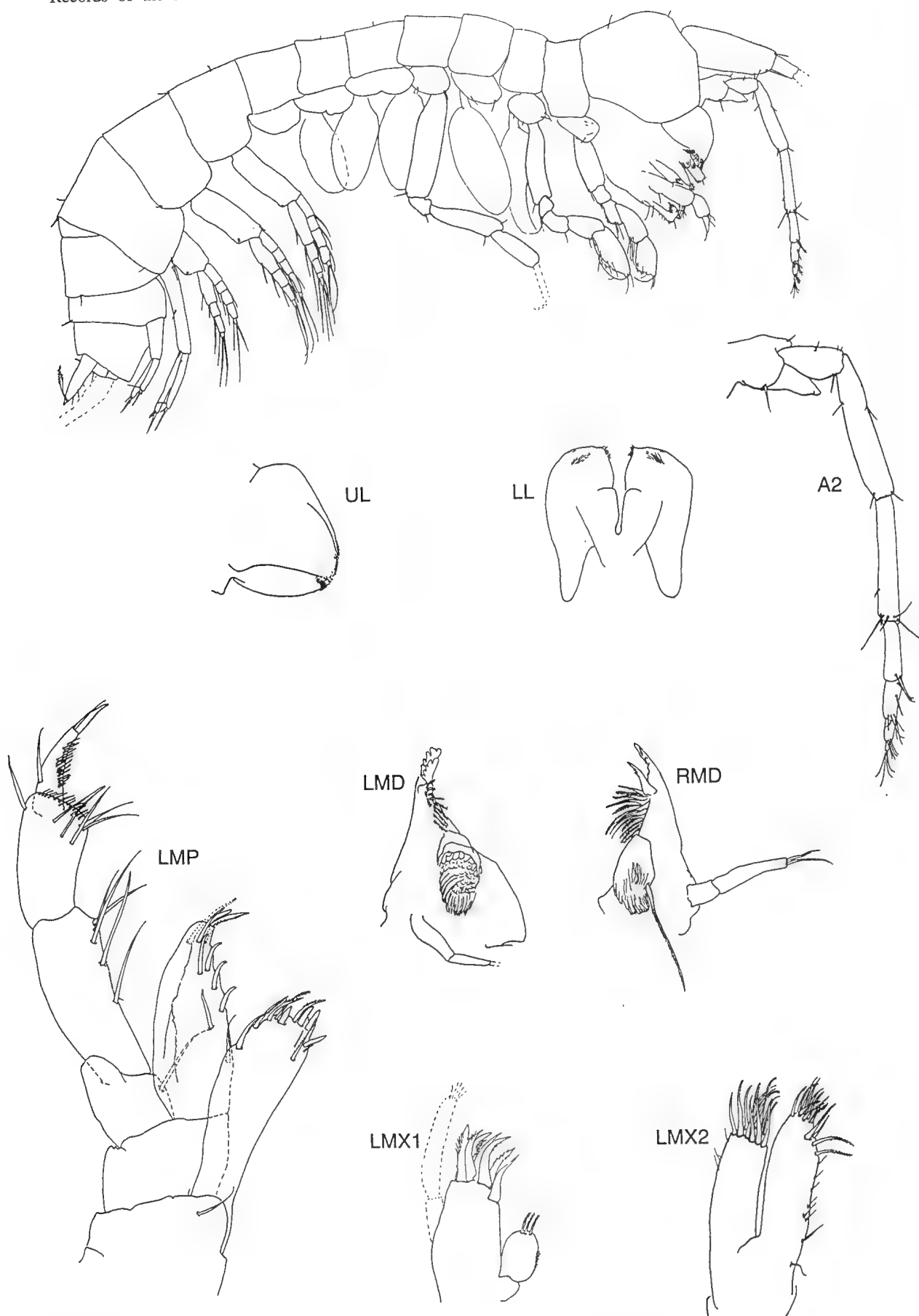


Fig. 14. *Nedsia fragilis* holotype male 2.4 mm. Body, antenna, mouthparts.

*Nedsia fragilis* n.sp.

Figs 14, 15

**Etymology.** Named for the fragile nature of the appendages.

**Type locality.** Barrow Island, Western Australia., Western Australian Museum sampling site BES738.

**Material examined.** HOLOTYPE (Western Australian Museum WAM 5-96), male 2.4 mm.

**Diagnosis.** *First antenna* (broken in type specimen): ratio of peduncular articles = 82:23:–. *Upper lip*: symmetrical, not excavate below. *Right mandible*: bearing inter-raker plumose setae, *left mandible* without; palp 2-articulate, article-1 reduced, subtruncate; article-2 linear, subtruncate, setae = 2E. *Maxillae*: inner plate of both maxillae without pubescence of medial or lateral margins; outer plate of first maxilla bearing 5 denticulate and 2 naked terminal spines. *Coxae*: coxa 1 longer than broad, slightly expanded below, coxa 2 lacking posterior marginal spines, coxae 3–4 with posterior spines. *Maxilliped*: inner plate with distal row of 4 plumose setae, lacking medial plumose setae; outer plate medial margin barely sinuous, paired submarginal setae curved and blunt, reduced in number; apex of palp article-3 not produced, setae not organised into combs; dactyl bearing a row of comb setae, single dorsal spine seta, moderate nail and equally long accessory spine. *First gnathopod*: palmar spines curved, not bifid except at palmar corner where spines = 3 lateral, 2 medial. *Second gnathopod*: defining corner of palm bearing 1 long lateral seta and 1 slender medial trigger spine. *Epimera*: posteroventral tooth present on epimera 2–3, epimeron 3 with small ventromarginal spine at M0.6. *Pleopods*: peduncles without setae, basomedial setae of inner rami not bifid, 2 retinaculæ on each peduncle, without accessory retinaculum. *Uropods*: dorsal margins of peduncles of uropod 2 not spinous, spine rows of rami reduced to 0 or 1 spine each. *Telson*: cleft 100%; single distolateral spine at M0.8; single lateral penicillate setule at M0.7 on either lobe.

**Description of holotype (male).** *Body* 2.4 mm. *Urosome*: poorly armed dorsally. *Head* (Fig. 14): rostrum obsolescent; eyes absent. *First antenna* (Fig. 14): ratio of peduncle articles = 82:23:–. Setae of peduncular article-1 limited to single dorsal and ventral sub marginal setae, one submarginal ventral and one long mediodistal setae; article two naked. *Second antenna* (Fig. 14): length 0.3× body, peduncle longer than flagellum, article-4 longer than article-5 (63:52), articles 3–4–5 with weak ventral setation, article-3 with 1 dorsomedial spine, flagellum of 4 articles, without calceoli. *Upper lip* (Fig. 14): apical margin rounded, not excavate, connection to epistome symmetrical. *Mandibles* (Fig. 14): left mandibular palp of 2 articles (broken), incisor 5 toothed, lacinia mobilis 5 toothed, 6 barely setose accessory blades, no inter-raker plumose setae; molar

tritulative, lacking distal plumose seta, slight pubescence around base of accessory blades; right mandible incisor 5 toothed, lacinia mobilis denticulate, accessory blades of 6 plumose spines; molar tritulative, with distal plumose seta; palp 2-articulate, reduced, ratio of articles 2:16, articles truncate, naked, terminal article with 2 E-setae only. *Maxillae* (Fig. 14): first maxilla palp article-2 bearing (5 spines), outer plate with 7 spines; 2 naked, 5 denticulate, inner plate (bearing fine medial setae); second maxilla outer plate, outer apical margin lacking pubescence with few fine setae; inner plate lacking pubescence; terminal spines of both plates half rastellate, half finely setulate. *Maxilliped* (Fig. 14): palp article-3 with a pair of long subterminal setae medially, diagonal distal row of 3 facial setae, apex with subterminal transverse row of unorganised comb setae; nail of moderate length with an accessory spinule of equal length; palp article-2 bearing mid-medial serrations; inner plate with a pair of plumose facial spines and two distal submarginal medial spines, one small and sharp the other moderate, stout and blunt. *First gnathopod* (Fig. 15): coxal plate with 1 moderate apical seta, several (3) anterior and posterior (2) facial setae, without a posteroventral spine; article-4 posteriorly bulbous and pubescent; carpus not lobate; propodus trapezoidal, slightly expanded apically, longer than wide; posterior edge naked except for an apical pair of long setae basal to the dactyl; palmar corner rounded, marked by 3 naked lateral spines and 2 stout bifid medial spines; palm convex, finely serrated, dactylus reaching the end of the palm. *Second gnathopod* (Fig. 15): palm with 4 setae; 2 lateral, 2 medial, the fourth marking the corner medially, along with a strong elongate lateral spine; palm finely serrate along most of its length; dactyl bearing a single dorsal spinule at M0.3, and small bent spinule laterofacial at M0.6; coxal plate 2 broader than coxa 1, poorly setose with 1 posteroventral marginal spine and a ventrofacial spine both at M0.6, as well as a single anteroventral spine at M0.1. *Pereopods* (Fig. 15): coxa 3 with 1 anteroventral spine, 1 posteroventral submarginal seta-spine; coxa 4 similar; pereopods (3)–4 longer than gnathopod 2, pereopod (3) equal to pereopod 4; pereopod 4 articles 4–5 sparsely setose posteriorly, (pereopods 5–7 similar, consecutively elongate, with 2 locking spines, pereopod 7 article-6 anterior spines displaced by an anterior keel); coxae 5–7 bearing no setae on ventral margins of the posterior lobes, article-2 weakly expanded, (not lobate but extended posteriorly, with thin, short posterior setae); coxae 3–7 dactyls simple, with no accessory spinules. *Gills*: coxal gills of limbs 2–6 flask shaped, simple, gill 6 not reduced, gill coxa 2 largest, gill coxae 5–6 smallest but not significantly reduced. *Pleopods* (Fig. 15): two retinaculæ per pleopod, with no accessory retinaculæ; peduncle 2 only with apicolateral seta; rami extend subequally, outer rami with 5 articles each, the inner with 5–4–4; setae of the basal articles = 1–1–1–1, none are bifid. *Epimera* (Fig. 15): each posteroventrally quadrate, though epimeron 2 barely so; posterior margins scarcely convex, smooth, and barely setulose; epimeron 3 with 1 ventrofacial spine, lacking lateral oblique ridge.



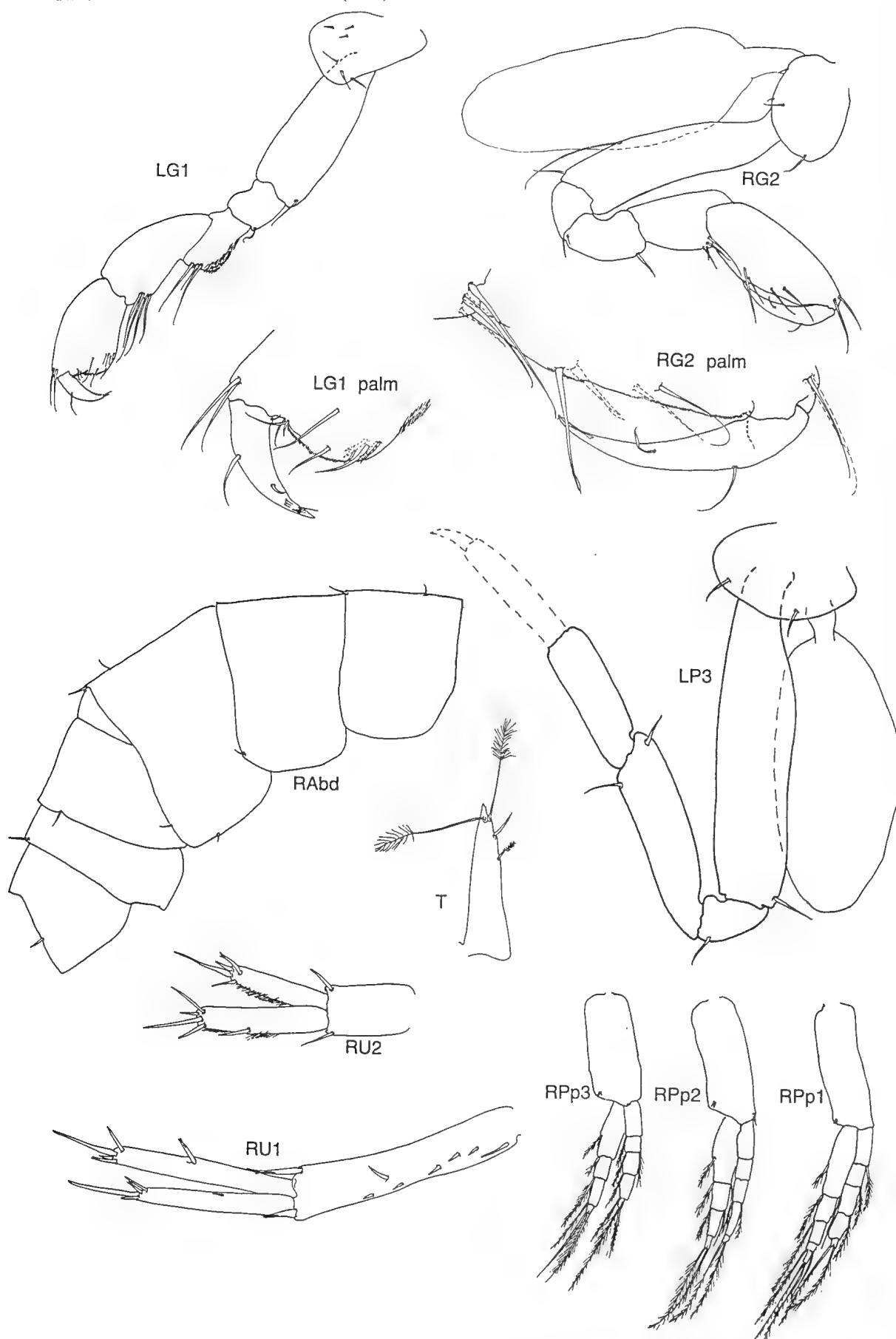


Fig. 15. *Nedsia fragilis* holotype male 2.4 mm. Legs, pleopods, uropods, telson, abdomen.

**Pleon** (Fig. 15): pleonite 2 only without dorsal or dorsolateral posterior setae; pleonite 6, no dorsolateral or distoventral spines. **Uropods** (Fig. 15): lengths relative to uropod 1—uropod 2 = 0.5, uropod 3 absent; uropod 1 peduncle length  $1.3\times$  medial ramus, outer margin with a row of 5 small submarginal spines and 1 moderate laterofacial spine at M0.6, single apicomедial and apicolateral trigger spines, basofacial spine weak, the medial ramus longer than the lateral; both rami with sparse setation, terminating in 4 spines; peduncle of second uropod  $0.6\times$  length of inner ramus, single apicomедial and apicolateral spines; medial margin of both rami pubescent; outer ramus shorter than inner (62:81), both bearing few marginal spines and 4 terminal spines; uropod 3 absent. **Telson** (Fig. 15): length  $1.6\times$  width, as long as urosomite 3, cleft 100%; apices notched, subapices with 2 long plumose setae; 1 marginal seta at M0.8, each lobe bearing a single penicillate setule marginal at M0.7.

**Relationship.** *Nedsia fragilis* varies from *N. douglasi* in the relative length of the second antenna, the greater length of the second peduncular article, the presence on the third article of a dorsomedial spine, a round and symmetrical upper lip, mandible bearing additional accessory blades, the molar bearing a distal plumose seta, palp of right mandible with elongate first article, second maxilla lacking pubescence, terminal spines of both plates either rastellate or terminally setulate, first gnathopod palmar corner rounded not square, with fewer medial spines, palm of second gnathopod with fewer spines, retinaculae of pleopods not associated with an accessory, rami of pleopods with fewer articles, epimera 2–3 without ventrofacial spines, pleonite 6 without dorsolateral or distoventral spinules or spines, basofacial spine weak, peduncle of the second uropod short and less spinous, rami marginally pubescent with fewer terminal spines, telson more slender. *Nedsia fragilis* differs from others of the genus in lacking marginal pubescence on both plates of the second maxilla, except for *N. straskraba*, from which it differs in possessing dorsal pleonal spines, and from *N. humphreysi* in lacking distolateral spines on the first epimeron, possessing a row of facial spines on the peduncle of the first uropod, the outer plate of the maxilliped tapers apically and is weakly cuspidate, and the palmar corner of the first gnathopod is rounded.

**Distribution.** Barrow Island, Western Australia.

*Nedsia macrosculptilis* n.sp.

Figs 16–18

**Etymology.** Named for the deep sculpturing of the pleon.

**Type locality.** Barrow Island, Western Australia, Western Australian Museum sampling site BES786.

**Material examined.** HOLOTYPE (Western Australian Museum WAM 6-96) female 5.5 mm Barrow Island, Western Australia.

**Diagnosis.** *Pleonites* 5–6: with 3 pairs of small dorsolateral spines. **Head:** rostrum absent, lateral cephalic lobes moderately projecting. **First antenna:** ratio of peduncular articles about 3:3.5:1. **Upper lip:** symmetrical, apically rounded. **Mandible:** palp of 2 small articles, truncate, cone like, setae of article 2 = 2E; accessory blades (rakers) = 5 right or 6 left with 3 right and 4 left interraker plumose setae between each main raker. **Maxillae:** first maxilla inner plate facially pubescent with 8 plumose medial setae, both plates of the second maxilla with distolateral fine pubescence, outer plate with fine pubescence medially. **Maxilliped:** medial setae of inner plate submarginal to facial, with 1 short, naked, submarginal spine at the base of the first of these, medial margin of face of outer plate scalloped and bearing rugosities; palp third article apex setae not organised to comb rows, apex not produced; dactyl facially setose with 2 medial and 1 terminal accessory spines, the latter as long as the moderate nail. **Coxae:** coxae 1–4 lacking posterior spines. **First gnathopod:** palmar spines symmetrically bifid, and without triggers, spines at corner of palm = lateral 4 long and medially a continuous row of 5 bifid and 2 naked spines, palmar edge finely serrated anteriorly. **Second gnathopod:** enlarged,  $2\times$  gnathopod 1, carpus moderate, shorter than propodus; defining corner of palm with 1 enlarged spine. **Epimera:** posterior margin of epimeron 3 sculptured; epimera with facial and ventral submarginal spines. **Coxal gills:** 5–6 reduced slightly. **Uropods:** rami of uropods 1–2 with 2 spine rows; uropod 3 medial setae of outer ramus moderately long; spines of peduncle apical and mid-lateral. **Telson:** cleft 100%.

**Description of holotype (female).** **Body** (Fig. 16) 5.5 mm. **Pleon:** pleonite 6 with 3 dorsolateral spines and 2 distoventral spines; pleonite 5 with 4 dorsolateral spines. **Head:** rostrum obsolescent; eyes absent. **First antenna** (Fig. 16): length about  $1.5\times$  body,  $2.9\times$  antenna-2, flagellum longer than peduncle, peduncle article-2 longest, 3 shortest, article-1 bearing a strong mediobasal spine; setae moderate, flagellum of many articles (44), and a few aesthetascs; accessory flagellum 2-articulate, 2nd article tiny; article-1 of primary flagellum fused, other articles shortest proximally, longest distally. **Second antenna** (Fig. 16): moderately short, length  $0.4\times$  body; peduncle longer than flagellum, articles 4–5 equally long, with weak ventral setation, article-3 without dorsomedial spines; flagellum 5-articulate, lacking calceoli. **Upper lip** (Fig. 16): apical margin convex, slightly extended, spinose and pilose, connection to epistome symmetrical. **Left mandible** (Fig. 16): left mandible palp missing, incisor 5 toothed, lacinia mobilis 5 toothed and very broad; 6 setose accessory blades; molar with distal plumose seta, triturative, an area of pubescence leading from accessory blades to the base of the molar. **Right mandible:** palp 2-articulate, reduced,

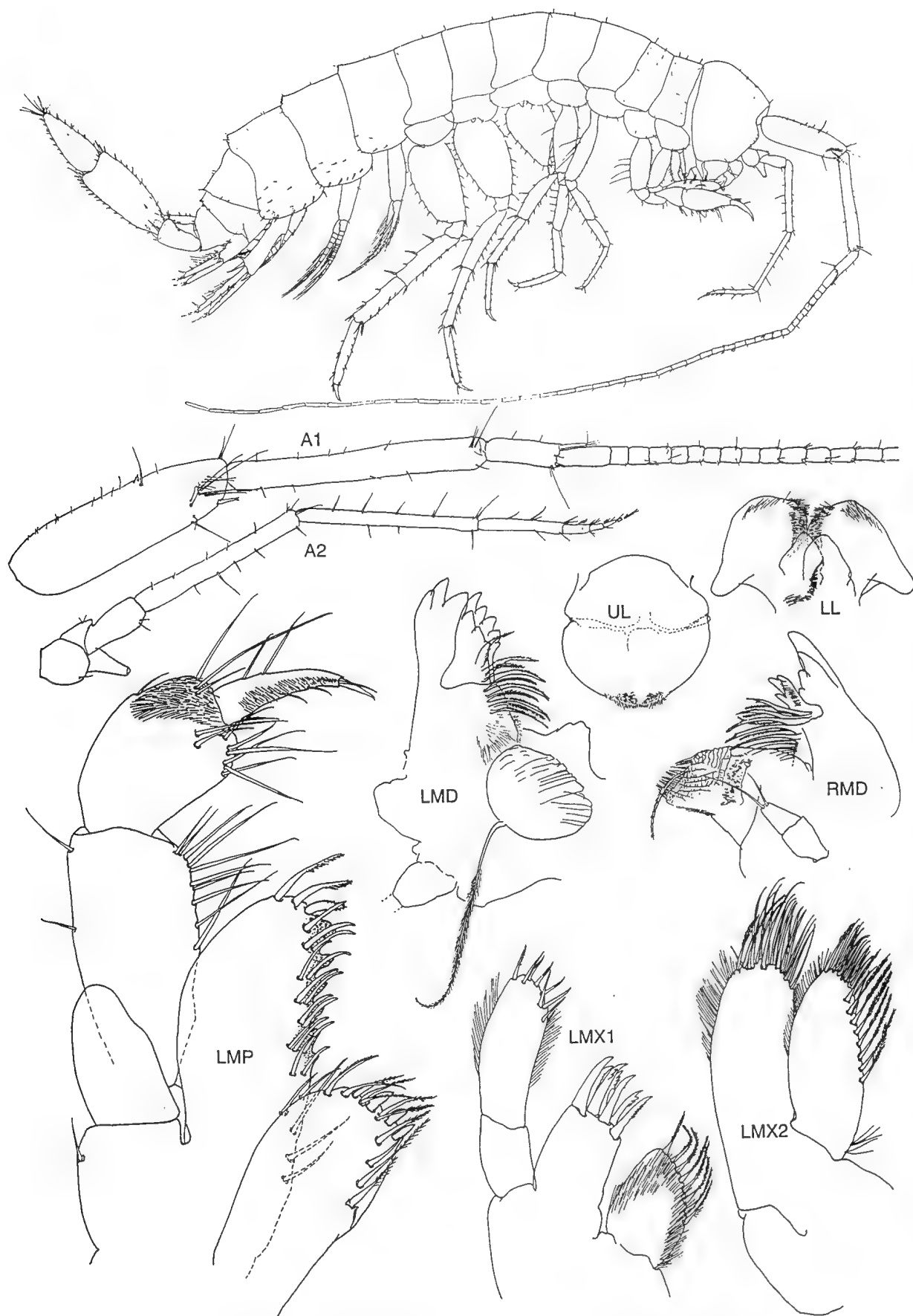


Fig. 16. *Nedsia macrosculptilis* holotype female 5.5 mm. Body, antennae, mouthparts.

article-1 short, naked, second article tapered, setae = 2E; lacinia mobilis with 3 smooth teeth and small denticle medial between 1st and last tooth, 5 setose accessory blades and 3 plumose interraker setae; line of pubescence leading to edge of molar. *Lower lip* (Fig. 16): bearing prominent inner lobes, outer lobes apically pilose and spinose. *First maxilla* (Fig. 16): right and left palp article-2 bearing 4 naked thin apical setae, 3 with fine distal setulate rugosities, and 1 plumose thin apical seta; outer plate with 6 denticulate, and 1 naked spines; inner plate ovate and pubescent, with 8 medial plumose setae. *Second maxilla*: both plates with the outer margin pubescent, as well as the median distal margin of the outer plate; basomedial margin of the inner plate with 5 fine setae grouped 2,3. *Maxilliped* (Fig. 16): palp article-3 with 2 thin, moderately long setae subdactylar on the inner face, and a longer pair on the outer face; article-3 moderately setose distally leading to the base of the dactyl. *First gnathopod* (Fig. 17): coxal plate with 5 short setae apically, without posterior ventral spines; article-4 posteriorly bulbous, marginally pubescent, but without a hyaline lobe; carpus not lobate, propodus trapezoidal, slightly expanded apically, longer than wide, posterior margin almost naked with 2 setae only; corner of palm rounded, not clearly defined, with row of 4 lateral setae, medially 2 naked spines and 5 bifid spines; palm convex, dactyl not reaching corner. *Second gnathopod* (Fig. 17): palm strongly oblique with 5 lateral and 2 medial spines all unevenly bifid with triggers; defining spine near corner medial, dactyl reaching spine, but not corner of palm; coxal plate broader than long, 4 anterior, 1 posterior setae. *Pereopods* (Fig. 17): coxa 3 with 3 anteroventral setae, similar; coxa 4 with 4 similar setae; pereopods 3-4 longer than gnathopod 2 (287,250:215), pereopod 3 shorter than pereopod 4, articles 4,5 sparsely setose posteriorly; posterior armament formulae of pereopods 3-4: S,S,S,S,S,0 and S,S,s,S,S,S thus with a single locking spine on pereopod 4 only; pereopods 5-7 similar but consecutively elongate, each with 3 locking spines; slight inward expansion of the anterior spines of article-6 of pereopod 7 revealing a slight keel; coxae 5-7 bearing single posteroventral setae on posterior lobes; article-2 of pereopods 5-7 moderately expanded, not lobate, but extended posteriorly, bearing short but moderately stout posterior setae; dactyls of pereopods 3-7 simple with single basal outer penicillate setule, and no accessory setules. *Gills*: of coxae 2-6 flask shaped, gills 5-6 smaller but not significantly reduced; gill 4 largest, gills 5-6 smallest. *Oostegites* (Fig. 17): of coxae 2 small, 3-5 thin, strap like, only those of coxa 5 with a few small setae. *Pleopods* (Fig. 18): retinaculae 2 each, no accessory retinaculae; peduncle of the first pleopod with no setae, of the second with 1 seta, of the third with 4; setae unevenly bifid with triggers; rami extending equally, the inner with 10,10,9 articles, the outer with 11,11, 10 articles. Setae on basal articles of rami = 1-1,1-1,1-0. *Epimera* (Fig. 18): epimera 1-2 posteroventrally subquadrate, epimeron 3 slightly lobate; posterior margins slightly convex, of epimeron 1 smooth, of epimeron 2 sculptured at the posteroventral corner and posteriorly sinuous, of epimeron 3 finely sculptured

posteriorly; epimera with facial and submarginal spines, posterior corners marked with 2-2-1 spines, each lacking an oblique ridge, but with an incomplete row of facial spines. *Pleon* (Fig. 18): pleonites 1-4 bearing dorsal and dorsolateral posterior setae, and posterior margins sculptured into sharp serrations; pleonites 4-6 with lateral and/or dorsolateral posterior spines—pleonite 4 with 2 lateral, pleonite 5 with 4 dorsolateral, pleonite 6 with 3 dorsolateral as well as 2 blunt ventrolateral spines. *Uropods* (Fig. 18): uropod 3 strongly extended in entire animal; uropod lengths relative to uropod 1—uropod 2 = 0.6×, uropod 3 = 1.3×; uropod 1 peduncle length subequal to inner, longer ramus (175:165), outer margin with 1 long apicodistal spine besides a row of 6 dorsal spines (the 6th spine subapical), one apicomедial spine and a medial row of 7 spines (the 7th spine subapical); rami of uropod 1 subequal in length, the medial ramus being the longer (155:165); both rami with two rows of marginal spines, and 5 terminal spines, distal margins of the inner ramus finely pubescent; uropod 2 peduncle 0.85× length of inner (longer) ramus, outer margin with 1 apicodorsal and 1 apicoventral spines, dorsolateral row of 5 unevenly spaced spines, medial margin with 2 apicoventral spines and 2 subdistal apicodorsal spines, 1 mid submarginal spine and a single basomarginal spine at M0.3; outer ramus shorter than inner, both with 2 rows of marginal spines in formulae 4,3 and 3,7; distolateral and medial margins of the outer ramus and both margins of the inner ramus finely pubescent; both rami terminating in 4 apical spines; uropod 3 peduncle length 0.24× outer ramus, longer than urosomite 3 (50:40), bearing an apical cluster of 4 dorsolateral spines, 1 mid-lateral spine; all spines marginal; outer ramus proximal article long, 2.3× peduncle, with lateral and medial marginal trigger spines, regularly spaced, an irregular, medial submarginal row of 4 small spines, one displaced toward the mid line, the medial and lateral apices each with a cluster of 4 spines extending partially across the distal margin; article-2 shorter, 0.8× article-1, margins bearing regularly spaced trigger spines, paired distally, the mediolateral and apical margins setate, setae increasing in length distally and with a single apical plumose seta; inner ramus scale like, of 1 article, length 0.1× the length of the proximal article of the outer ramus (16:117), bearing 1 short and 1 medium length apicolateral trigger spines and 1 postero-mid-lateral, submarginal medium-length trigger spine. *Telson* (Fig. 18): length 2.9× width, longer than urosomite 3 (47:40), cleft 100% of its length; subapices with sinuous lateral notch, long, paired, plumose setae arising subapically, a short row of 2 distal medial setae, 3 lateral trigger spines and weak dorsal setation; single small submarginal lateral penicillate setule at M0.6 on either lobe.

**Relationship.** *Nedsia macrosculptilis* varies from *N. douglasi* in that the pleon is more spinous and setous, the posterior margins of pleosome 1-4 finely sculpted and setate and of 5-6 dorsolaterally spinous, the flagellum of the first antenna extremely long bearing aesthetascs, the second peduncular article is longest, the first article

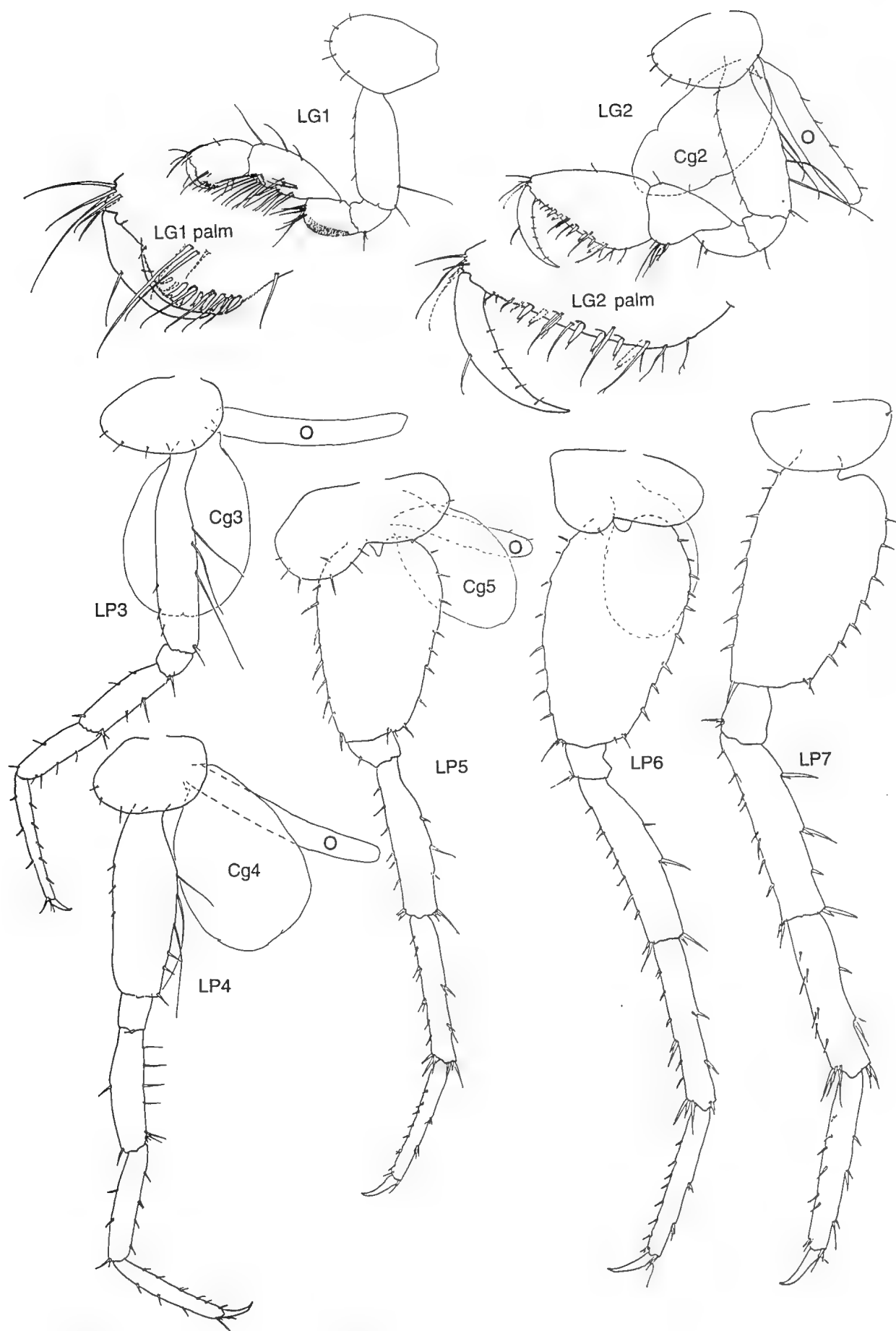


Fig. 17. *Nedsia macrosculptilis* holotype female 5.5 mm. Legs.

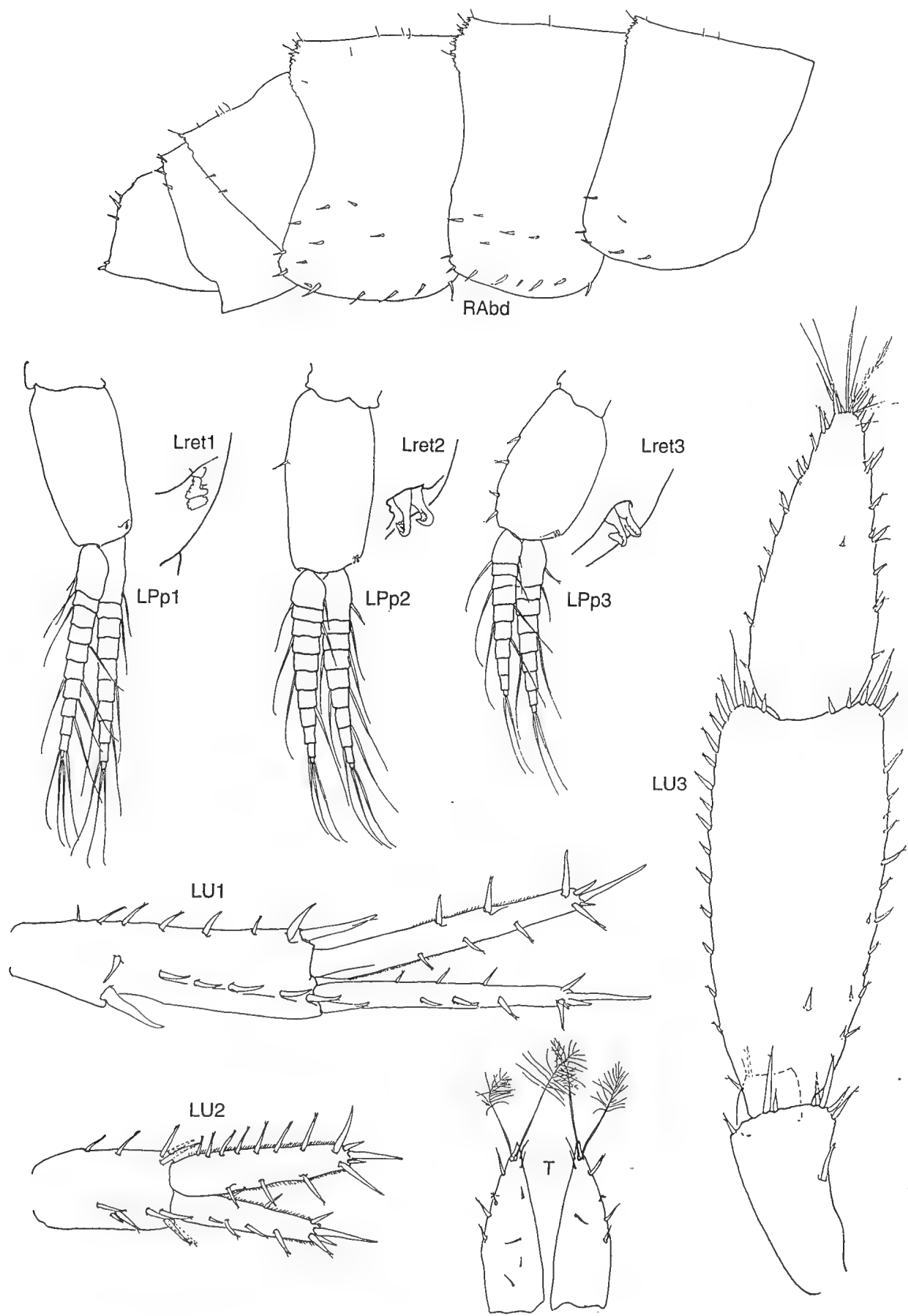


Fig. 18. *Nedsia macrosculptilis* holotype female 5.5 mm. Abdomen, pleopods, uropods, telson.

bearing a strong mediobasal spine, and moderately setate, the first article of the primary flagellum is fused and subsequent articles increase in length distally. The second antenna is proportionally longer, the flagellum 5-articulate, the upper lip is slightly convex apically, extended and symmetrical. Left molar bearing long plumose distal seta, is pubescent from the accessory blades to the base of the molar. Right mandibular palp 2-articulate, with a medium length plumose molarial seta, and pubescence. Palp of first maxilla bearing 8 thin apical setae, symmetrical, inner plate with 8 medial plumose setae, second maxilla basomedial margin of inner plate bearing 5 fine setae in 2 groups, maxillipedal palp article-3 with moderate distal setae leading to the base of the dactyl, gnathopod 1 palmar corner rounded, not clearly defined with more setae and spines. The second gnathopod is more spinous in the palm, epimera with facial and submarginal spines and posterior corners with 2-2-1 spines, pleon sculptured to sharp serrations, and bearing setae and dorsolateral spines on pleon 5-6, peduncle of uropod 1 shorter than in *N. douglasi*, distal margins of inner ramus finely pubescent, uropod 2 shorter, outer ramus shorter than inner, distolateral and medial margins of outer ramus and all of inner ramus covered in fine pubescence, uropod 3 peduncle longer than urosomite 3, all spines marginal, article-2 0.8× article-1, inner ramus relatively longer than in *N. douglasi*, telson much longer than wide, subapical notch broader, telson more spinous. *Nedsia macrosculptilis* differs from *N. sculptilis* in the absences of spines on the posterolateral margins of the fourth pleonite and of rugosity on the medial face of the maxillipedal outer plate, and in reduced scalloping of the medial margin of that plate. *Nedsia macrosculptilis* differs from all the other *Nedsia* in the presence of deep sculpturing of the pleonic posterior margins and of facial spines on the epimera. The species differs from *N. straskraba*, *N. fragilis* and *N. humphreysi* in bearing marginal pubescence on both plates of the second maxilla.

**Distribution.** Barrow Island, Western Australia.

*Nedsia sculptilis* n.sp.

Figs 19-21

**Etymology.** Named for the sculpturing of the pleon.

**Type locality.** Barrow Island, Western Australia. Western Australian Museum sampling site BES787.

**Material examined.** HOLOTYPE (Western Australian Museum WAM 7-96) male 4.0 mm.

**Diagnosis.** *Pleonites*: without dorsal spines. *Head*: rostrum obsolescent, lateral cephalic lobes moderately projecting. *First antenna*: bearing aesthetascs, *Second antenna*: short. *Upper lip*: symmetrical, not excavate. *Mandibular*

*palp*: 2-articulate, articles equal in length, terminal article tapered terminating in 2 E-setae; accessory blades on rakers = 6 left, 4 R, with one interraker plumose seta on the right and one additional seta beyond the left rakers. *Maxillae*: without medial setae or pubescence except for the lateral margins of the second maxilla; inner plate of the first maxilla ovato-triangular with six mid-medial to mediobasal plumose setae; palps symmetric; inner plate of the second maxilla with a row of medial setae barely extending onto the face apically with few other medial setae. *Coxae*: short, broader than long with few posterior spines. *Maxilliped*: inner plate bearing three distal plumose setae and three blunt naked terminal spines, without plumose medial setae, the outer plate bearing two distal plumose setae contiguous with a blunt naked tooth spine; palp articles 2-3 weakly setate laterally, setae at the dactylar base not organised into comb rows, the palp apex weakly produced, the dactyl with a moderately long nail. *First gnathopod*: palmar corner marked with one long lateral spine, moderate numbers of setae along palm. *Second gnathopod*: carpus barely lobate. *Pereopods*: 3-6 without accessory spinules on dactyls, posterior spine sets on article-6 of pereopod 3 evenly spaced, those on pereopod 4 uneven; dactyl of pereopod 7 with an extra terminal spinule. *Gills*: present on coxae 2-6. *Pleopods*: peduncles with 0,2,2 setae, 2 retinaculæ and no accessory retinaculæ. *Epimera*: epimeron 3 only with a small posteroventral tooth. *Uropods*: apicolateral corners of peduncles of uropods 1-2 with 3 and 2 spines respectively, the dorsal margins bearing few spines, the medial margin of uropod 1 with 2 apical spines. *Telson*: longer than broad, cleft 85%, bearing some medial spines.

**Description of holotype (male).** *Body* 4 mm. *Pleon*: pleonite 6 without dorsal spines, bearing two laterodistal and single ventrodistal spines; pleonite 5 with distal dorsolateral spines. *Head* (Fig. 19): rostrum obsolescent; eyes absent. *First antenna* (Fig. 19): longer than second (broken at article-11); flagellum longer than peduncle; peduncular articles 1-2 equal in length, 2.7× article-3, the first article bearing a cluster of ventral subdistal spines and setae, a row of small ventral spines, a dorsal row of three strong spines and a weak distal seta; flagellum moderately setate, bearing aesthetascs on some articles, article-1 of the primary flagellum fused, accessory flagellum 2-articulate, second article tiny, extending to 0.8 of the first article of the primary flagellum. *Second antenna* (Fig. 19): moderately short, 0.3× body length; peduncle longer than flagellum, articles 4-5 subequal with weak setation, article-3 bearing a single dorsomedial spine and 4 ventrodistal spines; flagellum of 5 articles of diminishing dimension, lacking calceoli or aesthetascs. *Upper lip* (Fig. 19): apically convex, pilose and spinose; symmetrical. *Left mandible* (Fig. 19): without palp (broken), incisor 5 toothed, lacinia mobilis 5 toothed and elongate, extending to the apex of the incisor; mandible bearing 6 large setose and 1 small naked accessory blades between the incisor and molar, without interraker plumose setae or pubescence; molar triturative, without



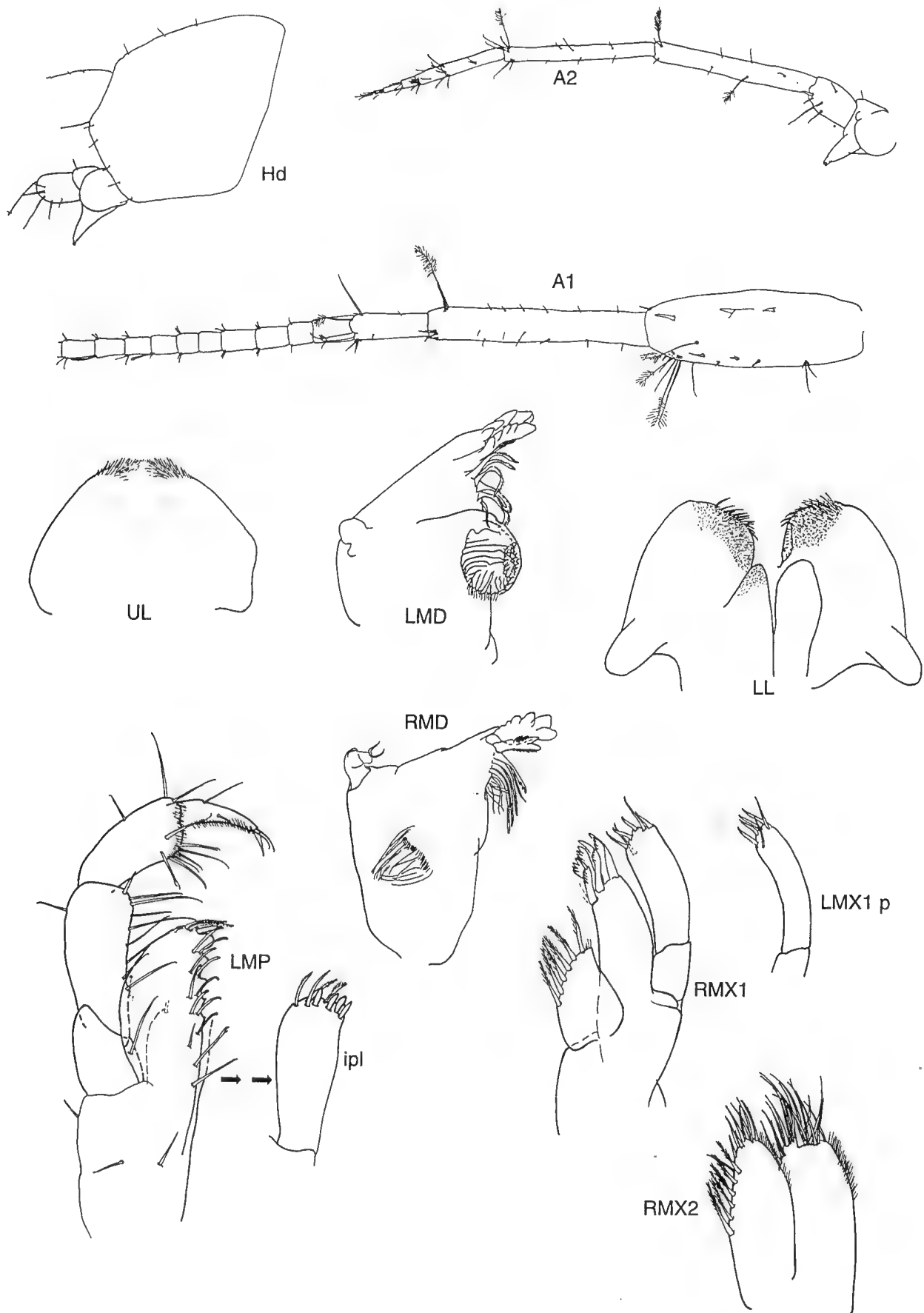


Fig. 19. *Nedsia sculptilis* holotype male 4 mm. Head, antennae, mouthparts.

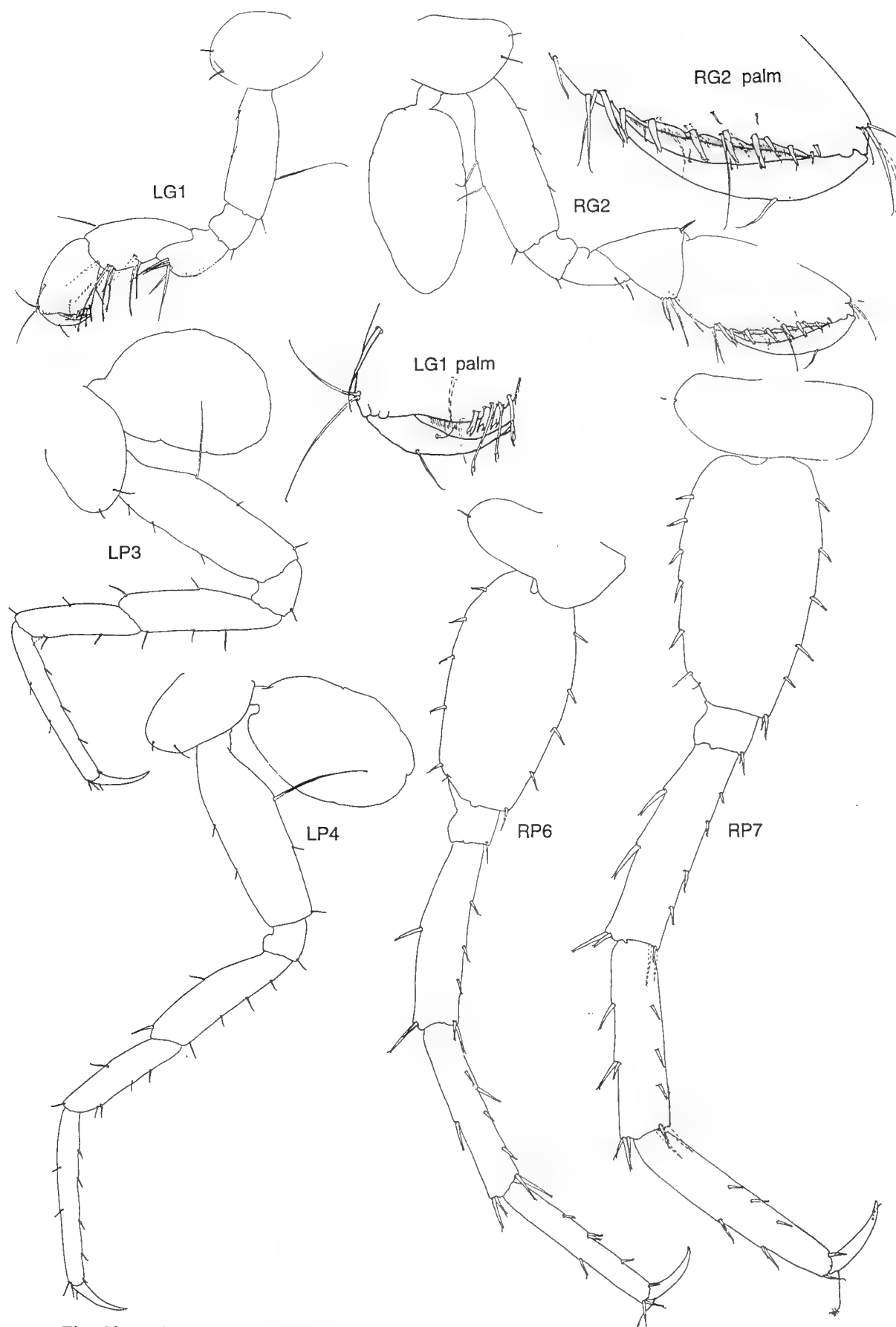


Fig. 20. *Nedsia sculptilis* holotype male 4 mm. Legs.

distal seta. *Right mandible* (Fig. 19): bearing a short palp of two subequal articles, the first truncate and naked, the second cone like bearing 2 short apical E-setae; incisor of 5 teeth; lacinia mobilis shorter than incisor, bifid, bearing anteriorly a median row of short spines, posteriorly a marginal row of setae; mandible bearing 4 accessory blades, the first denticulate, the remainder setose, with a single interraker seta lying between first and second blades, and a row of setae extending posteriorly; molar triturative, without a distal seta. *Lower lip* (Fig. 19): bearing prominent inner lobes extending to M0.7 of the outer lobes; anterior surfaces of both lobes rugose, inner lobes naked, outer lobes bearing apicomedial spines and setae. *First maxilla* (Fig. 19): palps of two articles, almost symmetrical, the left side more slender than the right, possibly regenerative, each with 5 apical and 1 subapical slender naked spines; inner plate ovatotriangular, without pubescence except for a small lateral terminal cluster, bearing on the medial margin to the apex 6 plumose setae; outer plate bearing two naked and five denticulate terminal spines. *Second maxilla* (Fig. 19): outer distal margin of both plates pubescent, facial and medial regions lacking pubescence, outer plate bearing a single distal spine additional to the terminal setae; both plates without other setae. *Maxilliped* (Fig. 19): palp third article with medial setae confined to the margin of the apex, bearing a single facial spine adjacent the dactylar base; apical setae marginal, not organised to comb rows; dactyl with two accessory spines arising adjacent the base of the nail and as long as the nail; medial margin of the outer plate carved into 4 sinuous indentations, without marginal spines, but associated with each a pair of long submarginal, curved, blunt spines. *First gnathopod* (Fig. 20): coxal plate bearing 2 apical setae, the fourth article posteriorly bulbous and pubescent, carpus not lobate; propodus trapezoidal and slightly expanded apically, longer than wide, posterior margin naked but for a single submarginal spine and a pair of long apical spines; margin of the palm lined with fine setae anteriorly, posteriorly the palmar corner rounded, marked by a single long lateral bifid spine, the posterior margin of the hand pubescent; adjacent the palmar corner three stout bifid spines and two long terminally bifid spines; dactyl bearing a subterminal accessory spinule extending to the nail-less apex, which reaches to the palmar corner. *Second gnathopod* (Fig. 20): coxa bearing 2 anterior setae, the palm strongly oblique, bearing 7 lateral and 2 medial stout trigger spines and marginally bordered with short setae, the palmar corner defined by a long lateral trigger spine; dactyl bearing 3 small spines along the inner margin, and extending to a point slightly short of the palmar corner. *Pereopods* (Fig. 20): coxae 3–4 with 2 anterior setae only, pereopods 3–4 longer than gnathopod 2, pereopod 3 < pereopod 4, both sparsely armed, pereopod 6–7 similar, pereopod 6 < pereopod 7, articles 5 of pereopod 6 and 5–6 of pereopod 7 bearing a slight anterior keel, the anterior spines consequently slightly submarginal; coxae 6–7 bearing single posterior spines, articles 2 of pereopods 6–7 posteriorly expanded but not lobate and bearing stout trigger spines; dactyls

of pereopods 3–6 without accessory spinules, pereopod 7 bearing a single subterminal spinule on the dactyl. *Gills*: flask shaped, present on coxae 2–6, gill 6 not reduced. *Sternal gills* absent. *Pleopods* (Fig. 21): each with 2 retinaculæ, without accessory retinaculæ, peduncles bearing 0,1,1 setae and 0,1,1 spines, all distal, the lateral spine of peduncle 3 bearing a trigger; rami extending subequally, of 7,6,6 inner and 8,8,7 outer articles; setae of basal articles of rami = 3-2,3-2,3-2. *Epimera* (Fig. 21): first epimera posteroventrally rounded, second posteroventrally quadrate, third slightly extended posteriorly and bearing a small posteroventral tooth, otherwise posterior margins smooth; epimera 1–3 bearing facial and submarginal ventral spines, the posterior corners marked by 2-1-1 spines, epimeron 2 bearing a single anteroventral marginal spine. *Pleon* (Fig. 21): pleonites 1–4 bearing dorsal and dorsolateral posterior setae, the posterior margins sculptured, with many serrations, less so on pleonite 4; without spines except for pleonite 5 which bears 3 dorsal and dorsolateral spines of moderate length, and pleonite 6 with 2 lateral and 1 ventrolateral posterior spines. *Uropods* (Fig. 21): first uropod 1.9× length of second, peduncle length greater than rami, outer margin bearing a strong basofacial spine and row of 4 dorsolateral spines, the last subapical, the medial margin bearing 2 anterior and 1 subapical dorsal spines; distal apices of peduncle bearing 1 medial and 1 lateral spines; inner ramus longer than outer, with single marginal spine at M0.6, and terminating in 5 spines, the outer ramus with 2 lateral spines at M0.4 and M0.6, terminating in an apical cluster of 4 spines; second uropod peduncle subequal to outer ramus, outer margin with 3 apical spines, inner margin with 1 mid-marginal and 3 apical spines; outer ramus bearing 1 mid-medial and 2 lateral spines at M0.5 and M0.7, and 4 terminal spines; inner ramus with 1 lateral spine at M0.7, a row of 4 medial spines and 4 terminal spines. Uropod 3 absent. *Telson* (Fig. 21): length equal to width, as long as urosomite 3; cleft 85% of its length, the subapex notched around an apical spine like extension, the notches bearing long plumose setae; left lobe bearing small lateral spines at M0.6 and M0.8, medial spines at M0.7 and M0.9, and a single penicillate facial setule at M0.5; right lobe bearing small lateral spines at M0.6 and M0.8, facial spines at M0.85, and single lateral penicillate spinule at M0.7.

**Relationship.** *Nedsia sculptilis* in the form of the pleonites which are setate and complexly sculptured, and the epimera which are facially and submarginally spinous is similar to *N. macrosculptilis* and differs from other *Nedsia* in these ways. *N. sculptilis* is distinguishable from *N. macrosculptilis* in that the posterior margins of the fourth pleonite are without spines, and the medial margin of the outer plate of the maxilliped is without facial rugosity and is carved into 4 rather than 5 indentations.

**Distribution.** Barrow Island, Western Australia.

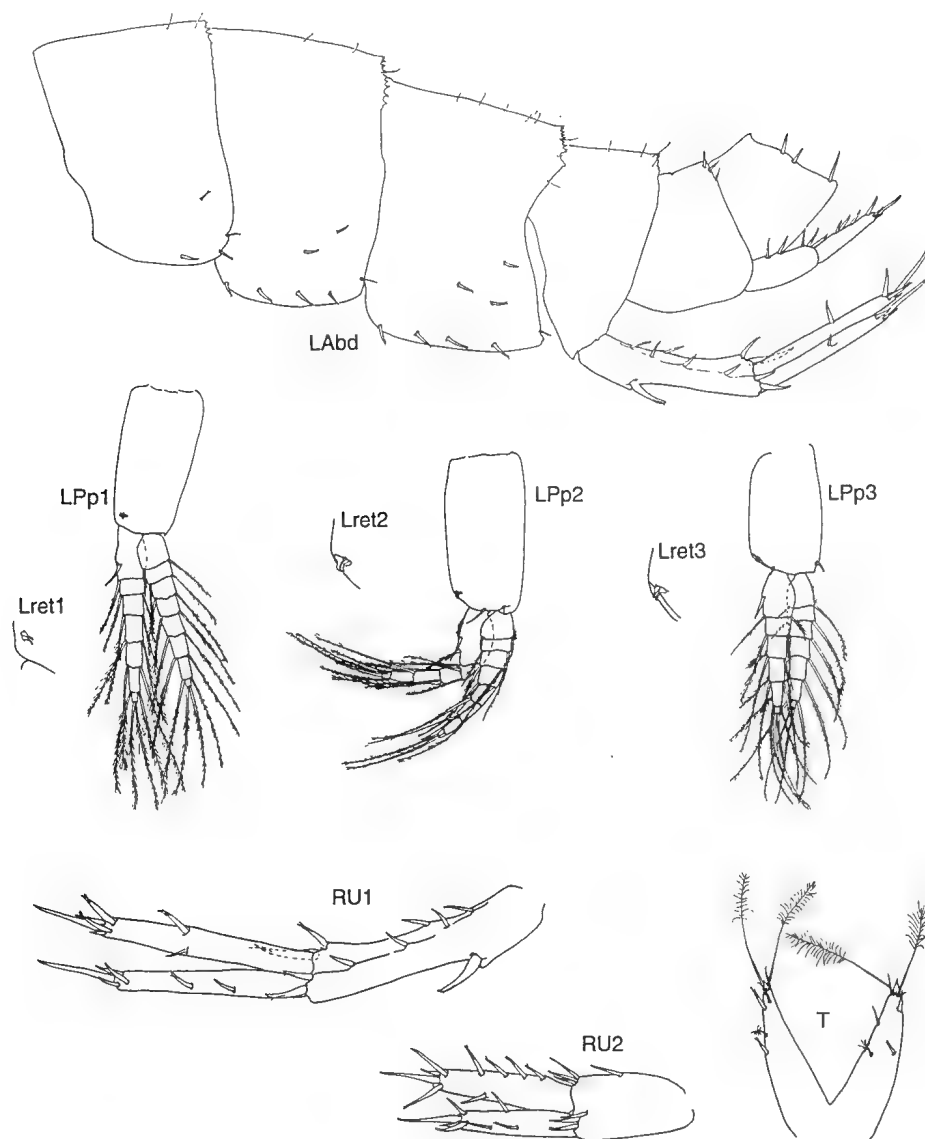


Fig. 21. *Nedsia sculptilis* holotype male 4 mm. Abdomen, pleopods, uropods, telson.

### Family Bogidiellidae

A species of this family is recorded from a single Barrow Island site described as cave WL8. This record of a bogidiellid from Western Australia is unique. While Stock (1984) recorded *Bogidiella* (*Xystriogidiella*) *capricornea* from Heron Island on the Great Barrier Reef, the nearest record is of *Bogidiella* (*Medigidiella*) *sarawacensis* Stock, 1983 from Sarawak.

All Bogidiellids are hypogean or interstitial stygobionts of marine and fresh waters. Holsinger (1993) records 86 subterranean species of 16 genera.

The species recorded here possesses Bogidiellid characteristics of vermiform body, absence of sternal gills, restriction of coxal gills to coxae 4-5-6 without reduction of the sixth gill, free urosomites, gnathopods not mittenform and the first gnathopod dominant, palmar spines simple, rami of uropod three equal and extended beyond the first and second in the entire animal and without article-2 of the outer ramus, the telson

uncleft and scarcely emarginate, pleopods uniramous, the lower lip broadly spread by forward extension of the inner lobes, setae of the terminal article of the mandible reduced, the maxillae reduced and without medial setae, and the maxilliped reduced (Barnard & Barnard, 1983).

### *Bogidomma* n.gen.

**Etymology.** Named for the presence of eyes, unique among the family.

**Type species.** *Bogidomma australis* n.sp.

**Diagnosis.** *Body:* pleonite 6 naked, rostrum obsolescent, lateral cephalic lobes strongly projecting, broad, with slight antennal sinus present; tending vermiform. *Urosome* without armaments. *Head:* first antenna moderately elongate, longer than antenna-2, ratio of peduncular articles 2:2:1, accessory flagellum 2-articulate; second

antenna, shorter than A1, flagellum much shorter than peduncle, calceoli absent. *Mandibles*: palp 3-articulate, ratio of articles 4:11:6, article-1 not setose, article-2 with few setae, article-3 with 2 E-setae only. *Lower lip*: broad, inner lobes elongate. *Maxillae*: without pubescence or peripheral setae except a single mid-medial seta on the inner plate of the second maxilla; inner plate of the first maxilla ovato-rectangular to subrectangular, without setae or pubescence, bearing 6 or 7 terminal spines, palp of two articles, with thin apical spines. *Coxae*: 1-7 short, longer than broad, coxae 1-2 lacking posterior spines, coxa 1 not expanded below, coxa 4 not excavate posteriorly, subquadrate, coxae 4-5 of approximately equal length, coxae 3-7 each with single posterior spines, coxae 1-4,6 each with single anterior spines. *Gnathopods*: similar. *First gnathopod*: dominant, hand ovate, carpus much shorter than propodus, strongly lobate, merus posteriorly extended but without hyaline lobe, palm strongly oblique, palmar spines not symmetrically bifid but with small trigger like extensions, spines at corner of palm; 2 long, lateral, 1 moderate medial; few simple setae along the palm; dactyl not reaching the end of the palm. *Second gnathopod*: smaller than gnathopod 1; carpus short, weakly lobate; hand moderately enlarged, ovate, palm acutely oblique, sparsely setulose, irregularly spinose; palm without distinct corner, bearing single slender medial and lateral trigger spines at point of intersection of dactyl. *Pereopods*: 6-7 moderately elongate, pereopod 7 longer than pereopod 6, pereopod 7 article-2 moderately expanded and posteriorly extended but lacking a posteroventral lobe; dactyls of pereopods 3-7 with 1 or 2 accessory spinules. *Gills*: coxae 4-6 each with a flask shaped gill; gill 6 not reduced; sternal gills absent. *Oostegites*: coxae 2-5 each with an elongate, thin, poorly setose oostegite. *Uropods*: uropod 3 extended beyond uropods 1-2 in entire animal, outer ramus with 1 article only, inner rami of equal length. *Telson*: broader than long, uncleft, laterally convex and terminally concave, subapical spines and paired penicillate setules on either lobule at M0.85.

**Additional description.** *Upper lip*: symmetrical, laterally and distally setose, weakly excavate below. *Mandibles*: accessory blades (rakers) few (3), with no inter-raker plumose setae, but a few additional plumose setae basal to the molar. *Maxilliped*: both plates short, inner plate bearing 3 long distal setae and 2 blunt naked tooth spines, but no other setae or pubescence; outer plate bearing 4 distal setae and a single medial seta at M0.5, medial margin otherwise without sinuities, setae or pubescence; palp long, articles 2-3 weakly setose medially, naked laterally, article-3 with a single comb row of fine setae at base of dactyl, few distomedial setal-spines, apex not produced; dactyl unguiform with an oblique row of comb setae, a slender, elongate nail and pair of terminal spines one of which is equal to the nail. *Gnathopods*: dactyls of gnathopods 1-2 without recumbent inner tooth spine, lacking nail; gnathopod 1 without rastellate seta of article-4. *Pereopods*: 3-4 smaller than pereopods 5-7; posterior spine sets of article-6 of pereopods 3-4

evenly spaced. *Pleopods*: similar, peduncles devoid of setae, each with a single outer ramus, no setae bifid; each peduncle with 2 retinaculæ, no accessory retinaculæ. *Epimera*: Post-ventral tooth of epimera 1-3 absent, posterior margins without spines or setae, smooth, slightly convex. *Uropods*: apicolateral corners of peduncles of uropods 1-2 with small single spines, dorsal margins without spines except for 1 medium size mid-dorsal spine at M0.85 on uropod 1; medial margin of uropods 1-2 with 1 apical spine; rami of uropods 1-2 subequal, without spine rows; uropod 1 without basofacial spine; uropod 3; medial setae of outer ramus absent; peduncle with 1 medial subdistal and 1 apicolateral spine. *Urosome*: ventrodistal spine on urosomite 1 at base of uropod 1 absent.

**Relationship.** This genus is unique among recorded bogidiellids in possessing well-developed eyes. All previously recorded bogidiellids are without eyes (Stock, 1984). Except in the presence of eyes *Bogidomma* is unequivocally a bogidiellid. Absence of inner rami of the pleopods suggests it is closest to either *Bollegidia* or *Bogidiella*.

Bogidiellids are categorised by Barnard & Barnard (1983) as probably a mixture of descendants from various Crangonyctoids. Barnard & Karaman (1980) discussed and dismissed Bousfield's (1977) elevation of the Bogidiellidae to superfamily status pointing out that the only consistent characteristic of the group is the dominant first gnathopod, a common occurrence among many groups, and therefore no basis for allocation to superfamily. Stock (1981) and subsequent authors have retained family status for this loose group characterised by a number of features which, however, do not all occur in all genera. Stock's (1981) cladistic analysis of the then known genera and species of the family translates into a position for *Bogidomma australis* somewhere within the *Bogidiella* group of subgenera, or possibly, though more remotely, on the basis of configuration of the lobes of the maxilliped, with *Marigidiella* (split from *Bogidiella*), although the new genus is unlike it in possessing two elements to the palp of the first maxilla, as well as a naked inner lobe and reduced setal cover of the second maxilla. Using the keys of Barnard & Barnard (1983), the new genus fits closely to *Bogidiella* except for the presence of eyes, ratio of the lengths of peduncular articles of the first antenna and of the length of the primary flagellum of the first antenna.

Geographically bogidiellids have been regarded as primarily Neotropical. They have, however, been reported from all the major continents, except Antarctica. The only record of a bogidiellid from Australia is of *Bogidiella* (*Xystriogidiella*) *capricornea* Stock, 1984, from the tropical marine atoll Heron Island, situated off the Pacific coast, a first recording of the family from the Pacific Ocean. *Bogidiella* is Palaearctic and Palaetropical (Oriental) as well as Neotropical (Hertzog, 1933; Stock, 1983). Stock (1983) considered the distribution of the Bogidiellidae can be explained as the result of the break up of Pangea in the Mesozoic and

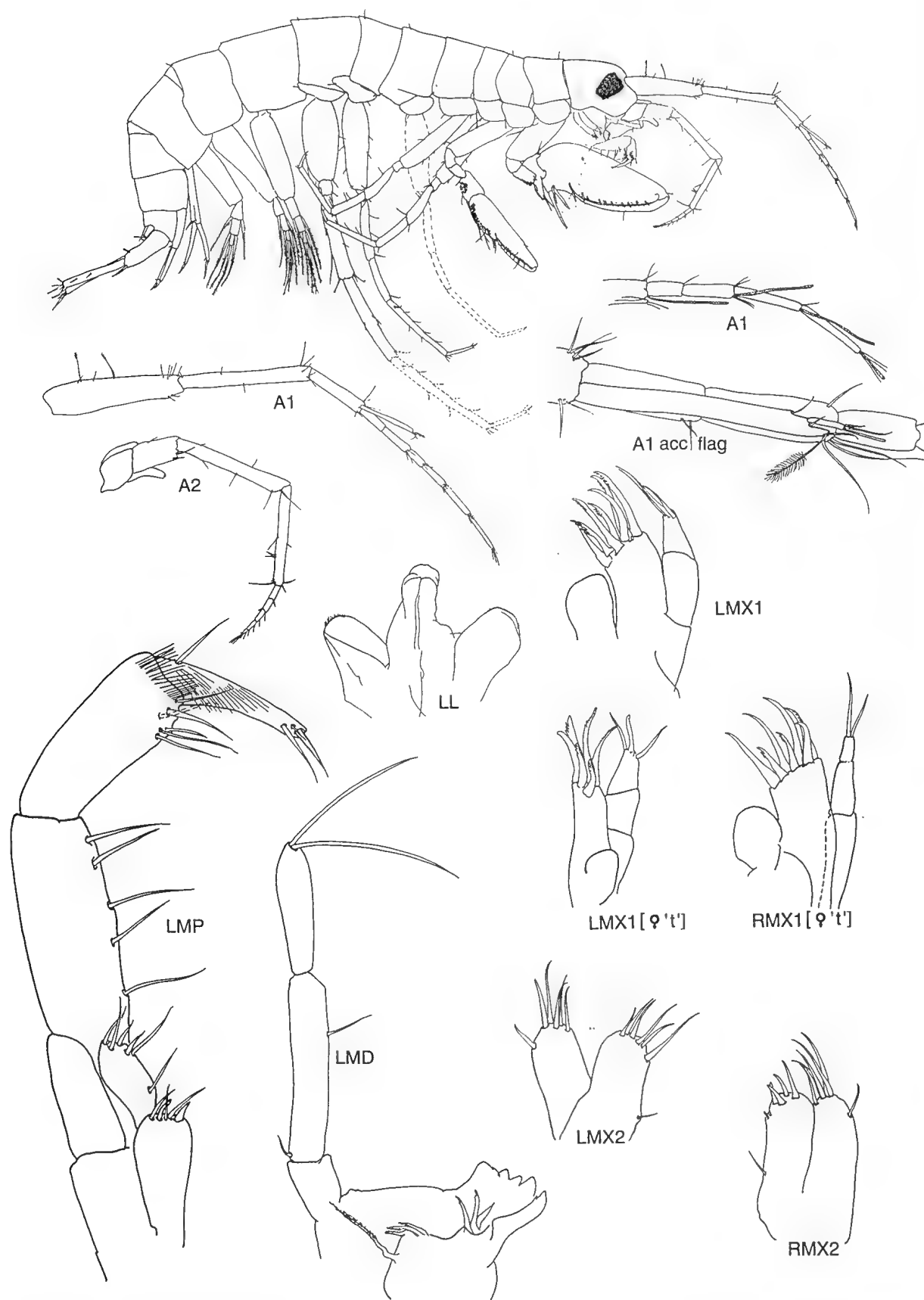


Fig. 22. *Bogidomma australis* holotype female 2.8 mm: all drawings except those indicated as female "t". Body, antennae, mouthparts.

isolation of populations in the Tertiary, and that the limited distributions and low fecundities of many species indicates their poor dispersive abilities.

*Bogidomma australis* n.sp.

Figs 22–24

**Etymology.** The name refers to the type locality region.

**Type locality.** Cave number WL8, Barrow Island, Western Australia.

**Material examined.** HOLOTYPE (Western Australian Museum WAM 8-96) Barrow Island, Western Australian Museum collection BES799, female 2.8 mm collected 2 December 1992. Other specimen: BES716 female "t" 2.5 mm (broken) collected 28 November 1992.

**Diagnosis.** As in the genus.

**Description of holotype (male).** *Body* (Fig. 22) 2.8 mm; urosome without armaments, length 2.5–3 mm. *Head:* rostrum absent; eyes present, large, about 0.3× head, ovate, pale and indistinct in the preserved specimen; antennal sinus absent except for a small concavity of the ventral lateral cephalic lobes. *First antenna* (Fig. 22): length 0.4× body, 1.5× antenna-2; primary flagellum of 6 articles, shorter than peduncle (120:200); peduncular articles 1 and 2 equal, article-3 shortest, setae sparse; primary flagellum with aesthetascs but without calceoli, article-3 smallest, remainder of uniform length, sparsely setulate; accessory flagellum 2-articulate, (Fig. 22) extending to M0.1 of the third article of the primary flagellum; second article tiny (1:8), articulated subdistally and extending only 0.4 of its length beyond the terminus of the first. *Second antenna* (Fig. 22): short, length 0.3× body, peduncle much longer than flagellum (195:35), articles 4–5 longest, articles 3–5 with weak ventral setation and a weak single mid-dorsal seta; article-4 with proximal and mid-dorsal setae; flagellum of 5 articles of progressively reduced length, all articles with weak dorsal setation; calceoli absent. *Upper lip* (Fig. 22): symmetrical, laterally and distally setose. *Mandibles* (Fig. 22): similar; palp 3-articulate, article-1 short, ratio of article lengths 4:11:6, article-3 with 2 apical setae (2E) only, incisor 4 toothed, lacinia mobilis bifid, with 3 setose accessory blades, and a short row of 3 plumose setae leading to the molar; molar indistinct, weakly or non-triturative, bearing distal plumose seta; no other pubescence. *Lower lip* (Fig. 22): outer lobes finely pilose apically, spread broadly by forward intrusion of elongate inner lobes; inner lobes naked, projecting beyond outer lobes, relative lengths; 33:23. *First maxilla* (Fig. 22): first maxilla asymmetric; palps of two articles, left palp with 3 apical spines, right palp with 2; left outer plate with 5 denticulate spines and 1 or 2 naked spines all of approximately equal length, right outer plate with 3

short denticulate spines, 1 short and 3 long curved, naked spines. *Second maxilla:* both plates without pubescence, asymmetric; left inner plate bearing 4 blunt apical spines and 2 short distomedial spines; right inner plate bearing 3 apical and 2 subapical slender, sharp spines, and an elongate slender distomedial spine which extends as far as the longest apical spines. *Maxilliped* (Fig. 22): palp article-3 with 3 distal and 3 apical spine-setae, nail of dactyl slender, with 2 subterminal setae, the longer extending as far as the nail itself; article-3 with a transverse comb-row of setae basal to the dactyl, the dactyl with basal setae and an oblique row of similar setae, as well as a single dorsal setule at M0.2. *First gnathopod* (Fig. 23): dominant, 1.5× gnathopod 2; article-4 posteriorly linear, carpus strongly lobate, propodus ovate, much longer than broad, tapering apically, posterior edge naked except for a single distal submarginal spine at M0.7; corner of palm recurved with 2 lateral and 1 medial spines, palm convex, finely serrated, spines and setae all submarginal, dactylus not reaching end of palm. *Second gnathopod* (Fig. 23): smaller than gnathopod 1; hand ovate, elongate, width 0.3× length; palm finely serrated, convex except at the posterior end where it is broadly sinuous, palmar spines and setae all submarginal, spines not symmetrically bifid but with triggers; dactyl not reaching palmar corner, which is marked by a pair of slender trigger spines with a further slender spine posteriorly; hand facially and posteroventrally pubescent; carpus posteriorly pubescent; coxal plate subequal to coxa 1 with a single anteroventral spine. *Pereopods* (Fig. 23): pereopods 3–4 shorter than gnathopod 1, pereopod 3 longer than gnathopod 2, pereopod 4 subequal to gnathopod 2, pereopod 3 longer than pereopod 4, pereopods 3–4 articles 1–5 sparsely setose posteriorly and anteriorly, posterior margin of article-6 on pereopods 3–4 with armament formula S-S-S-Ss and S-S-S-S, thus with only 1 locking spine; pereopods 6–7 similar but consecutively elongate, with 2 locking spines on pereopod 6; article-2 of pereopod 7 weakly expanded, but not posteriorly lobate, without posterior setae; article-2 of pereopod 6 not expanded with few posterior setae; dactyls of pereopods 3,4,6 bearing 2,2,1 accessory spinules. *Gills* (Fig. 24): of coxae 4–6 flask shaped, of coxa 6 not reduced. *Oostegites* (Fig. 24): strap like, length 0.5× article-2 of pereopods, bearing few distal setae. *Pleopods* (Fig. 24): similar. Retinaculae 2 per pleopod without accessory, peduncles without setae, each uniramous, the outer ramus only present, of 3 articles, each article with 2 plumose setae, none bifid. *Epimera* (Fig. 24): epimera 2–3 post ventrally quadrate, epimeron 3 slightly extended, epimeron 1 more rounded, subquadrate; posterior margins slightly convex, smooth, without setae or spines, without a lateral ridge. *Pleon* (Fig. 24): only pleonites 2–3 with a single posterior dorsolateral seta on either side; posterior margins of 1–3 convex, remainder linear, all smooth, without setae or teeth except as above. *Uropods* (Fig. 24): uropod 3 longest, extending beyond uropods 1–2 in the entire animal; uropod lengths relative to uropod 1—uropod 2 = 0.75, uropod 3 = 1.3; peduncle length



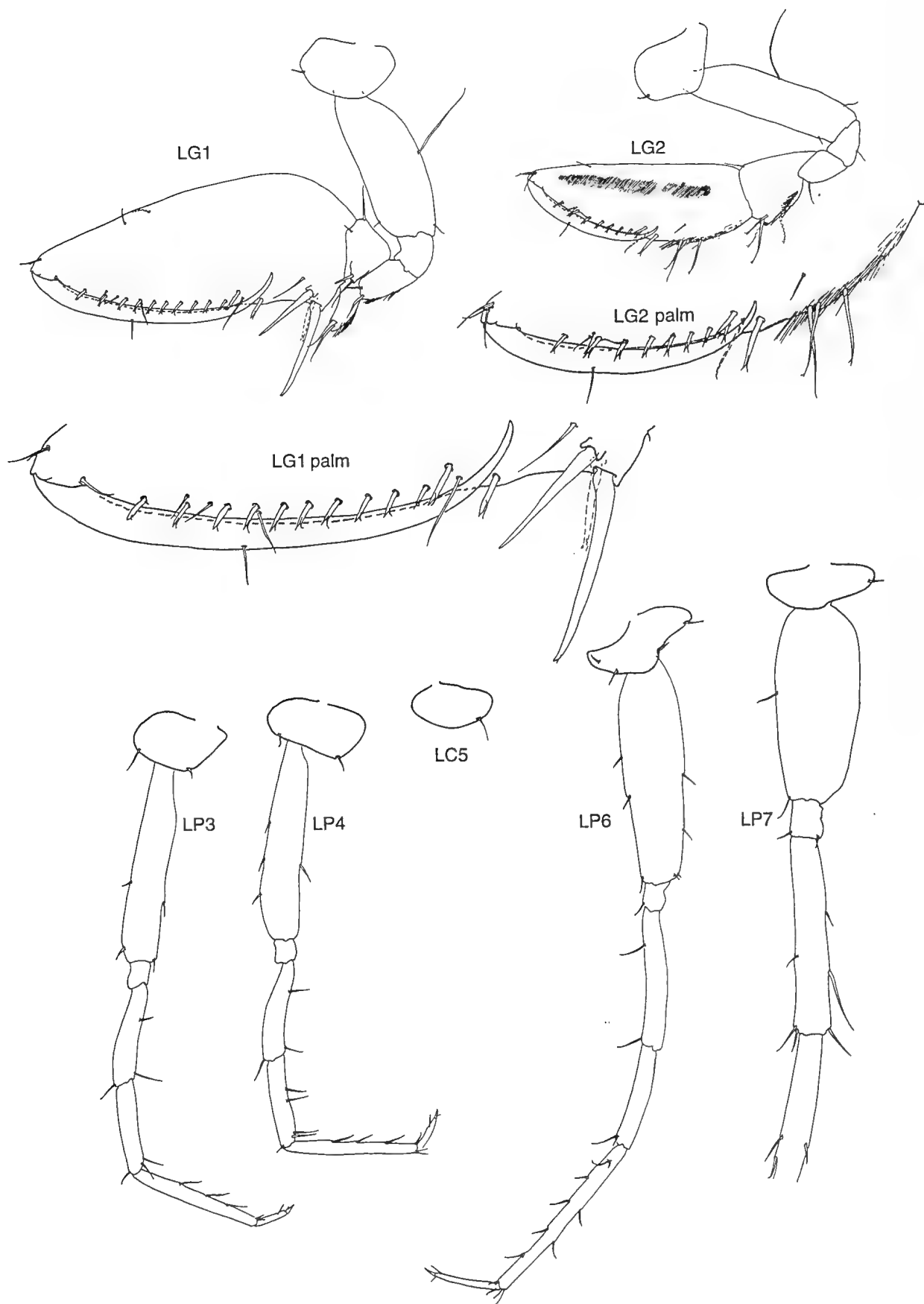


Fig. 23. *Bogidomma australis* holotype female 2.8 mm. Legs.

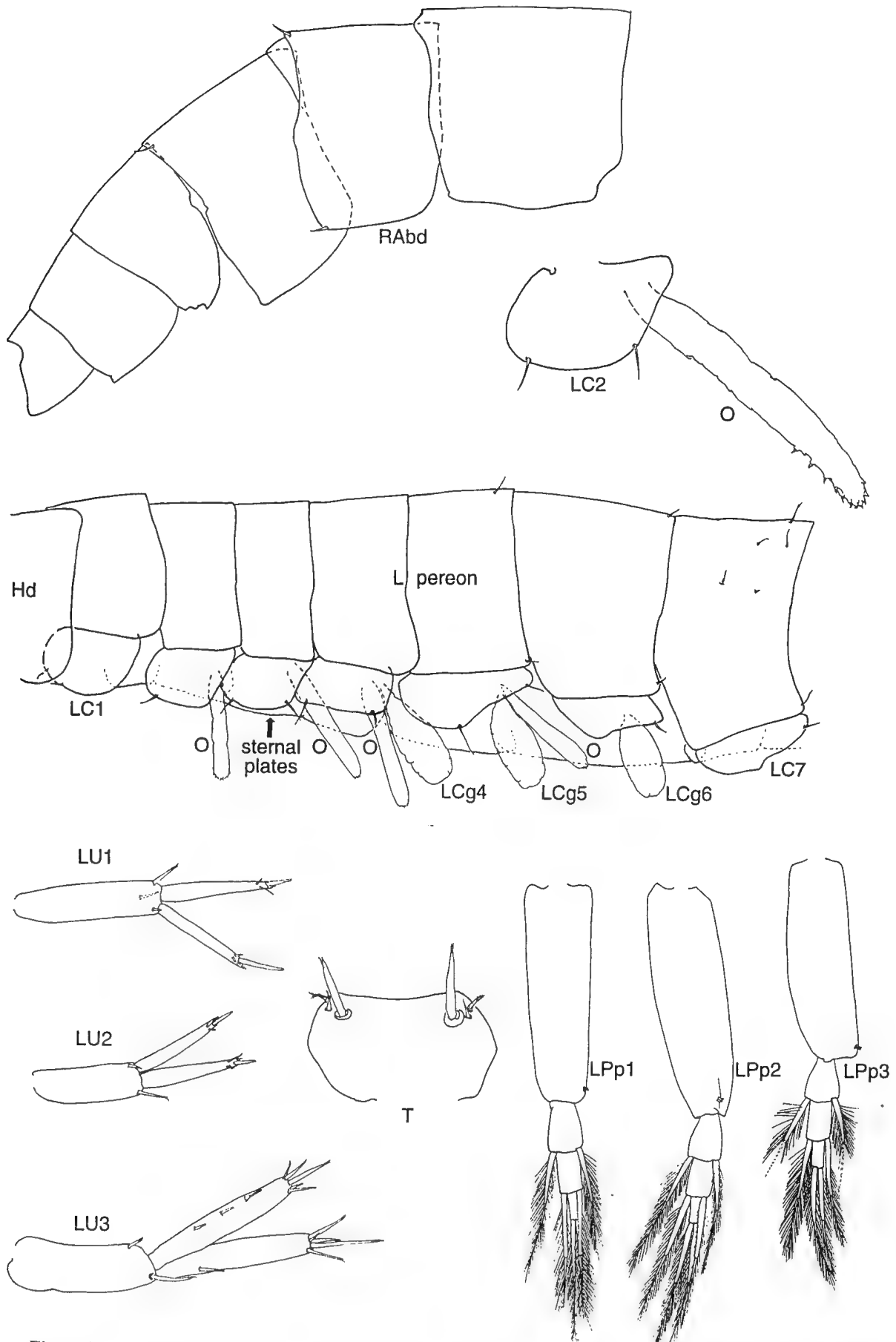


Fig. 24. *Bogidomma australis* holotype female 2.8 mm. Abdomen, gills and oostegites, pleopods, uropods, telson.

of uropod 1 =  $1.3\times$  inner ramus, outer margin with 1 small apicodistal spine, inner apical margin with a single, longer spine, without dorsal spine rows except for a single mid-dorsal spine at M0.85; rami of subequal length, lacking marginal spines; terminal spines = 5 lateral, 4 medial, the basal pair on each displaced subapically; uropod 2 peduncle length equal to length of inner ramus; peduncle naked except for a single apicomedial and a smaller apicolateral spine; outer ramus  $0.9\times$  inner; both rami without marginal spines, terminal spines = 4 lateral, 5 medial, several displaced subapically; uropod 3 rami equal in length; peduncle length  $0.85\times$  rami,  $3\times$  urosomite 3, bearing a single long apicolateral spine, and single smaller, apicomedial spine (the medial apex rounded, not subquadrate as is the lateral, thus displacing the apical spine subapically); outer ramus bearing a single laterofacial spine at M0.3 and 5 terminal spines; inner ramus bearing a row of 3 dorsomedial spines and 5 terminal spines. *Telson* (Fig. 24): width  $1.8\times$  length, approximately equal to, urosomite 3, not cleft, the apex concave to M0.9; 1 large trigger spine and 1 smaller spine submarginal, subapical on either lobe; paired penicillate setules at M0.85 on either side, submarginal on the left side.

**Distribution.** Barrow Island, Western Australia, in cave.

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## **The *Erichthonius* Group, a New Perspective on an Old Problem (Crustacea: Amphipoda: Corophioidea)**

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**ABSTRACT.** The *Erichthonius* group is established based on corophioid taxa with dorsal spines on the telson. Within this group there are three non-aligned genera (*Erichthonius*, *Pseuderichthonius* and *Pseudischyrocerus*) and two robust clades known as the *Cerapus* clade and the *Siphonoecetes* clade. The *Cerapus* clade (five genera) is defined by four synapomorphic characters: a posteriorly directed dactylus on peraeopod 7; accessory spines on the dactyli of peraeopods 5–7; uniramous uropod 2; and rows of recurved spines on the telson. The *Siphonoecetes* clade (10 genera, Siphonoecetinae of Just, 1983) is defined by: five synapomorphic characters: a short, slender first antenna; a reduced mandibular palp; a simple or weakly subchelate male gnathopod 2; an anteriorly inserted carpus on peraeopods 5–6; and no recurved distal spines on the rami of uropod 3. The relationships between these taxa are discussed and the *Cerapus* clade and the *Siphonoecetes* clade are considered to be sister taxa. Although the *Erichthonius* group is an obvious member of the Corophioidea there is currently no evidence to place it in an existing family. All genera in the *Cerapus* clade (*Bathypoma* n.gen., *Cerapus* Say, 1817, *Notopoma* n.gen., *Runanga* J.L. Barnard, 1961, and *Paracerapus* Budnikova, 1989) are diagnosed and a number of species are placed in new combinations. The two new genera, *Bathypoma* and *Notopoma*, are both characterised by a medially expanded peduncle on antenna 1 which functions as an operculum and distinguishes them from all other members of the group. *Bathypoma enigma* n.sp. is the only member of the *Cerapus* clade with a subchelate gnathopod 2 in the male. *Notopoma* contains *N. africana* n.sp., *N. crassicornis* (Bate, 1857), *N. fallohidea* (Lowry, 1981), *N. harfoota* (Lowry, 1981), *N. lutkini* (Tzvetkova, 1990), *N. moorea* n.sp., *N. opposita* (K.H. Barnard, 1931), *N. sismithi* (Stebbing, 1888), *N. stoddartae* n.sp. and *N. stoora* (Lowry, 1981). A generic key to the *Erichthonius* group is included.

LOWRY, J.K. & P.B. BERENTS, 1996. The *Erichthonius* group, a new perspective on an old problem (Crustacea: Amphipoda: Corophioidea). Records of the Australian Museum 48(1): 75–109.

There has been much discussion in the literature concerning family level taxa in the Corophioidea. J.L. Barnard (1973) established the superfamily Corophioidea for all taxa with a "fleshy" telson (Aoridae, Ampithoidae, Cheluridae, Corophiidae, Isaeidae (= Photidae), Ischyroceridae and Podoceridae (= Dulichiidae)). In that study Barnard included several family groups (Aoridae, Isaeidae) in the Corophiidae.

Bousfield (1973, 1978), Myers (1974, 1981) and Just (1983) have all been sceptical of Barnard's broad concept of the Corophiidae. Myers (1981) and Just (1983) have shown that there are suprageneric taxa among the corophioids which can be differentiated on distinctive synapomorphic characters. Myers (1981) recognised the Aoridae, Corophiidae and Isaeidae and established the new family Neomegamphopidae.

Just (1983) established the Siphonocetinae in the Corophiidae *sensu stricto*. Just (1988) analysed the phylogenetic relationships within this group using the *Cerapus* complex of Lowry (1985) for outgroup comparisons. Just (1988) raised the point that members of the *Cerapus* clade were placed in the Ischyroceridae and members of the *Siphonocetes* clade were placed in the Corophiidae, but in his opinion "cerapids" and "siphonocetids" were sister taxa and the *Cerapus* clade members appeared to be more closely related to the Corophiidae (*sensu* Myers, 1981; Just, 1983).

Barnard & Karaman (1991) were not moved by these arguments and re-amalgamated these families so that the Corophioidea contained the Ampithoidae, Cheluridae, Corophiidae (Aoridae, Corophiidae, Isaeidae, Ischyroceridae) and Podoceridae. They recognised the Siphonocetinae as a separate taxon within the Corophiidae, but not the subfamily taxon Aorinae established by Myers (1988).

We are investigating this complex problem using cladistic methodology. Our current analyses have not produced clades which we can reconcile with current hierarchical classifications. In this paper we present a cladogram based on all corophioid taxa which have some form of spines on the telson, referred to here as the *Erichthonius* group. We prefer to leave these clades as informal groups until our analyses are completed. The purpose of this cladogram is to indicate the position of the *Cerapus* clade within the context of its presumed sister taxa and to show the relationships between genera in the group. We discuss in detail only the genera of the *Cerapus* clade.

Lowry (1981) suggested the need for a taxon to include species in which the peduncular article 1 of the first antenna was produced anterodistally and medially to form an operculum for closing the tube. The recent redescription of *Cerapus tubularis*, the type species of the genus (Lowry & Berents, 1989), has permitted a new evaluation of genera in the *Cerapus* clade. In our studies of Indo-Pacific taxa several new species with this type of peduncle have been discovered. We describe them below in the new genera *Notopoma* and *Bathypoma*.

In this paper we use the modified scheme of Lowry & Stoddart (1993) for delineating setae on the mandibular

palp and the terminology changes for setae and spines implemented by Lowry & Stoddart (1995). These changes were based primarily on arguments about the homology of setae and spines presented by Oshel & Steele (1988) and Watling (1989). The terminology mainly follows Watling (1989) with a few modifications. Structures which were previously referred to as setae are now referred to as setae or slender setae and what were previously referred to as spines are now called robust setae. Structures which were previously referred to, mainly as, teeth (non-articulating extrusions of the cuticle), are now referred to as spines.

All morphological characters are stored in a DELTA data base (Dallwitz & Paine, 1986) known as CERADEL. The key to genera and all descriptions have been produced from DELTA. The "id" ending is occasionally used for convenience to replace a group name. In this context it has no hierarchical implications.

The following abbreviations are used in the text: AM, Australian Museum, Sydney; BMNH, The Natural History Museum, London; NMV, Museum of Victoria, Melbourne; SAM, South African Museum, Cape Town; USNM, United States National Museum of Natural History, Washington, D.C.

The following abbreviations are used on the plates: A, antenna; C, coxa; D, dactylus; E, epistome; G, gnathopod; MD, mandible; MP, maxilliped; MX, maxilla; P, peraeopod; PL, pleopod; T, telson; U, uropod; UR, urosome; l, left; r, right.

## Phylogenetics

### Included Taxa

Taxa belonging to the Corophioidea are considered to be monophyletic because they all have a fleshy telson (J.L. Barnard, 1973). The *Erichthonius* group is considered here to be a monophyletic group within the Corophioidea because all taxa included in the group have dorsal telsonic spines. This conclusion is based on supporting analyses (Lowry & Berents, unpublished) which include all ischyrocerid and corophiid (*sensu stricto*) generic taxa. These analyses indicate that dorsal telsonic spines have evolved only once within the Corophioidea. Fifteen genera have these dorsal spines. An additional three genera (*Concholestes*, *Polynesoecetes* and *Siphonocetes*) do not have spines, but are aligned with the group because they are well known siphonocetid taxa which are presumed to have lost their spines.

The *Erichthonius* group (or erichthoniids) contains: genera previously aligned with the Ischyroceridae (Barnard & Karaman, 1991) (*Cerapus* Say, 1817; *Erichthonius* Milne Edwards, 1830; *Pseudierichthonius* Schellenberg, 1926; *Pseudischyrocerus* Schellenberg, 1931 and *Runanga* J.L. Barnard, 1961); genera considered by Just (1983) and Barnard & Karaman (1991) to be in the subfamily Siphonocetinae (*Africoecetes* Just, 1983;

*Australoecetes* Just, 1983; *Borneoecetes* Barnard & Thomas, 1984; *Bubocorophium* Karaman, 1981; *Caribboecetes* Just, 1983; *Concholestes* Giles, 1888; *Corocubanus* Ortiz & Nazbul, 1984; *Rhinoecetes* Just, 1983; *Siphonoecetes* Krøyer, 1845; recently described non-aligned genera (*Paracerapus* Budnikova, 1989; *Polynesoecetes* Myers, 1989); and new genera described herein (*Bathypoma* and *Notopoma*).

The corophioid genus *Gammaropsis*, is used as the outgroup for this analysis because it is considered to be the least specialised living corophioid genus (Barnard & Barnard, 1983). The question of immediate sister groups for the *Erichthonius* group is not being considered in this analysis.

### Character Description

1. Antenna 1, length in relation to antenna 2. In *Gammaropsis* the length of antenna 1 is subequal to antenna 2 (Fig. 1.1a). In some erichthoniids it is shorter and often more slender (Fig. 1.1b).
2. Antenna 1, shape of peduncular article 1. In *Gammaropsis* and most erichthoniids peduncular article 1 is long and rectangular (Fig. 1.2a). In some genera peduncular article 1 is produced anterodistally and medially (Fig. 1.2b).
3. Antenna 1, accessory flagellum. In *Gammaropsis* and some erichthoniids the accessory flagellum is multiarticulate (Fig. 1.3a). Within the erichthoniids it may be vestigial (Fig. 1.3b) or absent.
4. Mandibular palp. In *Gammaropsis* and most erichthoniids the mandibular palp is well developed and 3-articulate (Fig. 1.4a). In some erichthoniids it is reduced and 2-articulate (Fig. 1.4b).
5. Gnathopod 2 male. In the corophioids the male gnathopod 2 is usually much larger than that of the female. It may be subchelate (Fig. 1.5a), carpochelelate (Fig. 1.5b) or simple (Fig. 1.5c).
6. Gnathopod 2 male, carpus. In *Gammaropsis* the carpus of gnathopod 2 is shorter than the propodus (Fig. 1.6a). The carpus may be subequal to the propodus (Fig. 1.6b) or longer and larger than the propodus (Fig. 1.6c).
7. Coxa 4. In *Gammaropsis* coxa 4 is as deep as wide (Fig. 1.7a). Coxa 4 may be wider than deep (Fig. 1.7b) or deeper than wide (Fig. 1.7c).
8. Coxa 4. In *Gammaropsis* and most erichthoniids the ventral margin of coxa 4 is smooth (Fig. 1.8a). In some taxa the ventral margin is serrated (Fig. 1.8b).
9. Peraeopod 5 dactylus. The distal part of peraeopod 5 (at least the propodus and dactylus) is directed anteriorly in *Gammaropsis* (Fig. 2.9a). In some erichthoniids the distal part of peraeopod 5 is directed posteriorly (Fig. 2.9b). In *Corocubanus* the distal part of peraeopod 5 is apparently absent.
10. Peraeopod 6 dactylus. The distal part of peraeopod 6 (at least the propodus and dactylus) is directed anteriorly in *Gammaropsis* (Fig. 2.10a). In some erichthoniids it is directed posteriorly (Fig. 2.10b). In *Corocubanus* the distal part of peraeopod 6 is apparently absent.
11. Peraeopod 7 dactylus. The distal part of peraeopod 7 (at least the propodus and dactylus) is directed anteriorly in *Gammaropsis* (Fig. 2.11a). In some erichthoniids it is directed posteriorly (Fig. 2.11b). In *Corocubanus* it is vestigial.
12. Coxa 5. In *Gammaropsis* the coxa 5 has a posterodorsal lobe (Fig. 2.12a). Within the erichthoniids the posterodorsal lobe is occasionally absent (Fig. 2.12b).
13. Peraeopod 5 carpus. In *Gammaropsis* and some erichthoniids the carpus of peraeopod 5 is without denticles or spines (Fig. 2.13a). Within the *Cerapus* and *Siphonoecetes* clades the carpus may have denticles (Fig. 2.13b) or denticles and short spines on a posteroventral lobe (Fig. 2.13c).
14. Peraeopods 5–6 propodus. In *Gammaropsis* and some erichthoniids the propodus is inserted at the distal end of the carpus (Fig. 2.14a). In other taxa the propodus is inserted on the anterior concave side of the carpus of peraeopod 5 or peraeopods 5 and 6 (Fig. 2.14b).
15. Peraeopods 5–7 dactylus. In *Gammaropsis* and some erichthoniids the dactylus has no accessory spines (Fig. 2.15a). In some erichthoniids spines may be present (Fig. 2.15b).
16. Uropod 1 peduncle. In *Gammaropsis* and some erichthoniids there is no distoventral corona (Fig. 2.16a). In other erichthoniids a distoventral corona is present (Fig. 2.16b).
17. Uropod 2 rami. In *Gammaropsis* and some erichthoniids uropod 2 is biramous (Fig. 2.17a). In other erichthoniids uropod 2 is uniramous (Fig. 2.17b) or absent (Fig. 2.17c).
18. Uropod 3 rami. In *Gammaropsis* and some erichthoniids uropod 3 is biramous (Fig. 2.18a). In other erichthoniids uropod 3 may be uniramous (Fig. 2.18b) or the rami may be absent (Fig. 2.18c).
19. Uropod 3 rami. *Gammaropsis* does not have recurved spines on the rami of uropod 3 (Fig. 2.19a). Within the erichthoniids some taxa have recurved spines (Fig. 2.19b).
20. Telson. In *Gammaropsis* and most erichthoniids the telson is entire (Fig. 2.20a). In the *Cerapus* and *Siphonoecetes* clades some taxa have a cleft telson (Fig. 2.20b).
21. Telson. In *Gammaropsis* there are no recurved spines on the telson (Fig. 2.21a). In erichthoniids there are recurved spines in patches (Fig. 2.21b) or rows (Fig. 2.21c) on the dorsum of the telson.

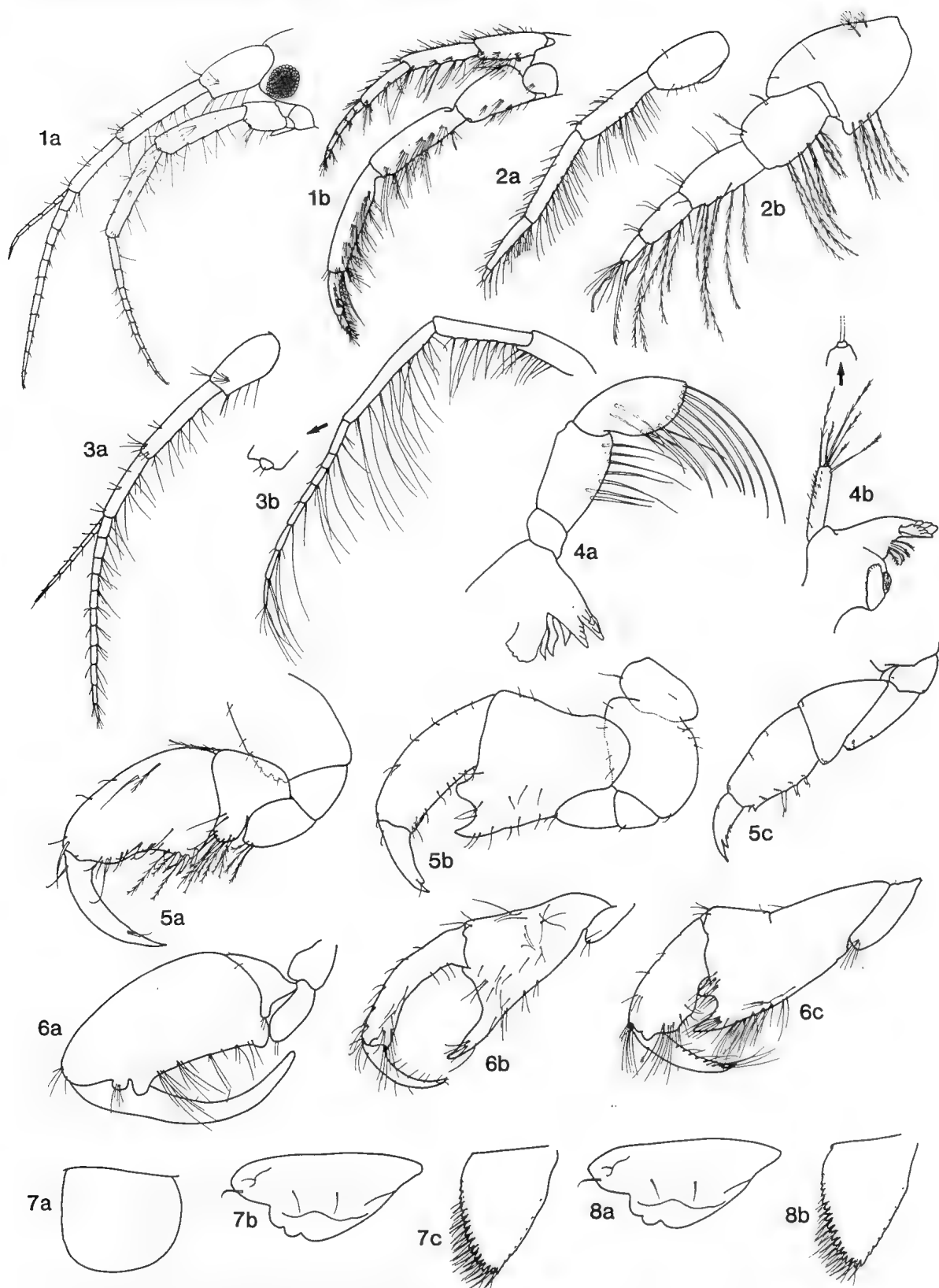


Fig. 1. Character states used in phylogenetic analyses. Antenna 1, subequal in length to antenna 2 (1a); shorter than antenna 2 (1b). Antenna 1, peduncular article 1 slender, rectangular (2a); peduncular article 1 expanded dorsomedially and dorsodistally (2b). Antenna 1 accessory flagellum multiarticulate (3a); vestigial (3b). Mandibular palp 3-articulate (4a); 2- or 1-articulate (4b). Gnathopod 2 male, subchelate (5a); carpochelate (5b); simple (5c). Gnathopod 2 male, shorter than propodus (6a); subequal to propodus (6b); longer and larger than propodus (6c). Coxa 4 as deep as wide (7a); wider than deep (7b); deeper than wide (7c). Coxa 4 ventral margin smooth (8a); ventral margin serrated (8b).



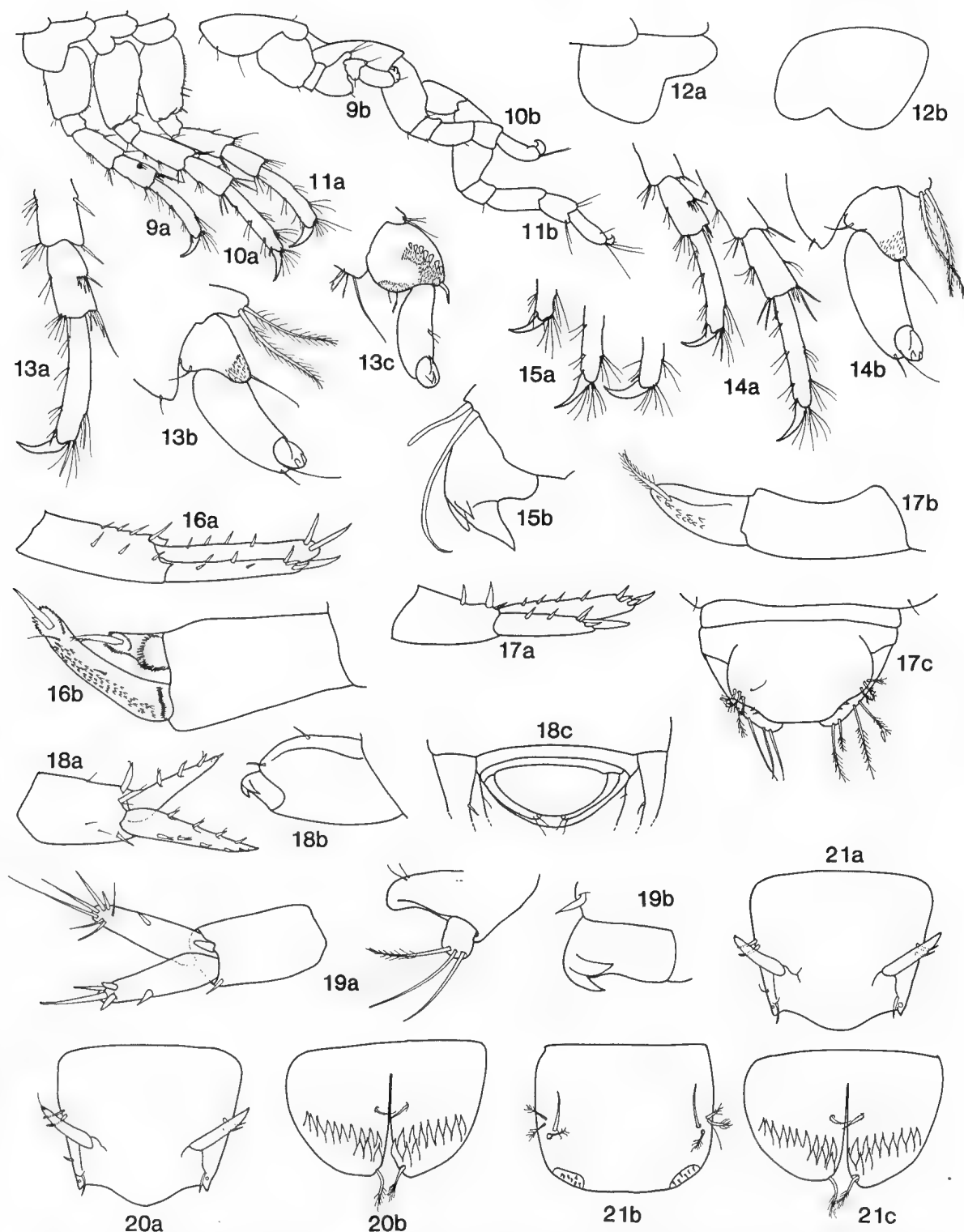


Fig. 2. Character states used in phylogenetic analyses. Peraeopods 5-7, distal part (at least propodus and dactylus) directed anteriorly (9a, 10a, 11a); directed posteriorly (9b, 10b, 11b). Coxa 5 with posterodorsal lobe (12a); without posterodorsal lobe (12b). Peraeopod 5 carpus without denticles or spines (13a); with denticles (13b); with denticles and short spines (13c). Peraeopods 5-6 propodus inserted at distal end of carpus (14a); inserted on anterior concave side of carpus (14b). Peraeopods 5-7 dactylus without accessory spines (15a); with accessory spines (15b). Uropod 1 peduncle without distoventral corona (16a); with distoventral corona (16b). Uropod 2 rami biramous (17a); uniramous (17b); without rami (17c). Uropod 3 rami biramous (18a); uniramous (18b); without rami (18c). Uropod 3 with apical setae (19a); with recurved spines (19b). Telson entire (20a); telson cleft (20b). Telson without recurved spines (21a); with recurved spines in patches (21b); in rows (21c).

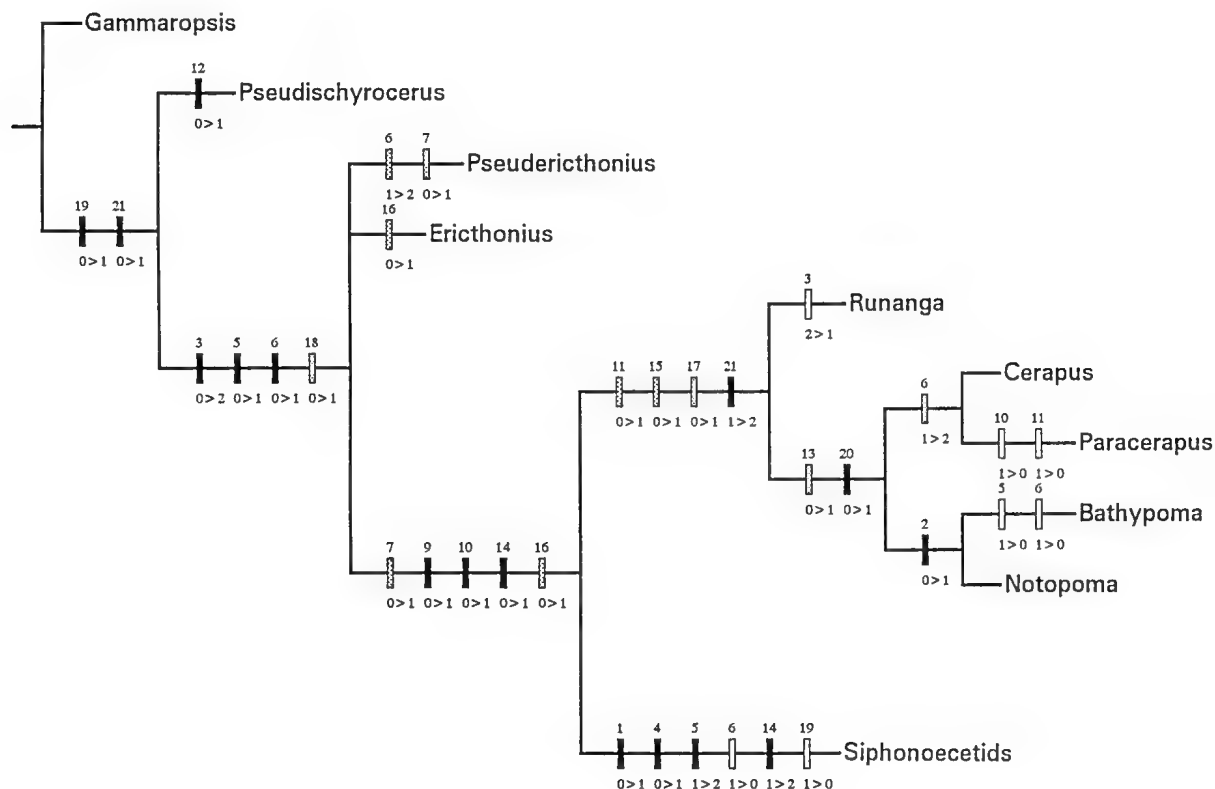


Fig. 3. Hypothesized phylogenetic relations among generic level tax. A black box indicates an apomorphic character; a shaded box indicates a homoplastic character; a white box indicates a reversal. Superscripts refer to characters and subscripts indicate direction. The *Siphonocetes* clade is represented as a terminal taxon.

### Methods and Results

The analyses were performed and examined using HENNIG86 (Farris, 1988) and CLADOS (Nixon, 1991). The matrix of the data is presented in Table 1. The HENNIG86 analyses were run using unordered characters. Implicit enumeration (ie) produced 6 trees (length 62, consistency index 0.54, retention index 0.76). In these six trees *Erichthionius* and *Pseuderichthionius* alternate in position and there is some instability in the position of taxa within the *Siphonocetes* clade. Using the HENNIG86 command, Nelsen, we generated a strict consensus tree (length 0.69, consistency index 0.49, retention index 0.72) (Fig. 3). Because of work in preparation (Just, pers. comm.) only the synapomorphies defining the *Siphonocetes* clade (10 genera) are presented and that clade is not discussed further.

### Relationships Within the *Erichthionius* Group

Our cladogram indicates three divisions within the *Erichthionius* group. There are three non-aligned genera (*Erichthionius*, *Pseuderichthionius* and *Pseudischyrocerus*) and two robust clades known as the *Cerapus* clade and the *Siphonocetes* clade. The *Cerapus* clade contains

*Bathypoma* n.gen.; *Cerapus* Say, 1817; *Notopoma* n.gen.; *Runanga* J.L. Barnard, 1961 and *Paracerapus* Budnikova, 1989. The *Siphonocetes* clade contains 10 genera listed above (*Siphonocetinae* of Just, 1988).

The *Erichthionius* group is defined by patches of small or large recurved spines on the dorsum of the telson [21]. The rami of uropod 3 also have recurved spines [19], however, in the *Siphonocetes* clade the plesiomorphic character state occurs, which we interpret as a loss.

The three non-aligned taxa occur near the base of the tree. *Pseudischyrocerus* is the only member of the *Erichthionius* group which does not have a posterodorsal lobe on coxa 5 [12,1]. *Pseuderichthionius* and *Erichthionius* form a dichotomy which would disappear if the taxa were synonymised.

The majority of the taxa in the *Erichthionius* group share four synapomorphic characters: the accessory flagellum is absent [3,2] (this character reverses in *Runanga* [3,1]); the male gnathopod 2 changes from subchelate [5,2]; the carpus of male gnathopod 2 becomes at least as long as the propodus (reverses in the *Siphonocetes* clade); uropod 3 becomes uniramous. The two sister clades (the *Cerapus* and *Siphonocetes* clades) in the *Erichthionius* group share five synapomorphic characters: coxa 4 becomes wider than deep [7,1] or deeper than wide [7,2]; the distal ends of pereopods

5 and 6 are directed posteriorly [9,1] [10,1] (in *Paracerapus*, this character reverses to the plesiomorphic state); in peraeopod 5 the propodus inserts on the anterior margin of the carpus [14,1]; and a distoventral corona of spines develops on the distoventral peduncular margin of uropod 1 [16,1] (changes state several times within the *Siphonoecetes* clade).

The *Cerapus* clade, with five genera, is defined by four synapomorphies: distal end of peraeopod 7 directed posteriorly [11,1] (homoplastic character reversed in *Paracerapus* and independently derived within the *Siphonoecetes* clade; accessory spines present on peraeopods 5–7 [15,1] (homoplastic character independently derived within the *Siphonoecetes* clade); uropod 2 uniramous [17,1] (homoplastic character independently derived within the *Siphonoecetes* clade); and telson with recurved spines in rows [21,2]. Three of these four characters also occur within the *Siphonoecetes* clade. The majority of taxa in both clades have a posteriorly directed dactylus on peraeopod 7. If the change to an anterior direction in *Paracerapus* and in *Siphonoecetes* is considered to be a reversal then the character also helps to define both clades. If no accessory spines on the dactyli of peraeopods 5 to 7 is considered to be a secondary loss in *Siphonoecetes*, then the presence of accessory spines may also be considered as a synapomorphy which helps to define both clades. However, uniramous second uropods in both clades appears to be the result of independently derived events. The recurved spines on the telson is consequently a strong synapomorphy which absolutely defines the *Cerapus* clade.

The *Cerapus* clade has five closely related genera. *Runanga* has the fewest derived characters and is defined by a vestigial accessory flagellum [3,1] (reversal). Other members of the *Cerapus* clade are distinguished from *Runanga* by denticles on the carpus of peraeopod 5 (homoplastic character independently derived within the *Siphonoecetes* clade) [13,1]; and a cleft telson [20,1]. *Cerapus* and *Paracerapus* are defined by having the carpus longer than the propodus in male gnathopod 2 [6,2]. *Paracerapus* differs from *Cerapus* in 'having the distal ends of peraeopods 6 and 7 directed anteriorly) [10,0] [11,0] (reversal to plesiomorphic state). *Bathypoma* and *Notopoma* are differentiated from other members of the *Cerapus* clade by the medially and distally expanded peduncle of antenna 1 [2,1]. *Bathypoma* differs from all other members of the *Cerapus* clade in having a subchelate gnathopod 2 [5,0] with short carpus [6,0] (an apparent reversal to the plesiomorphic state).

The *Siphonoecetes* clade is strongly defined by six synapomorphies: antenna 1 is shorter than antenna 2 [1,1]; the mandibular palp has 1 or 2 articles [4,1]; gnathopod 2 is simple [5,2] (in some genera a secondarily derived subchelate gnathopod develops); the carpus of gnathopod 2 is shorter than propodus (homoplastic) [6,0]; in peraeopods 5–6 the propodus inserts on the anterior margin of the carpus [14,2]; and there are no spines on the ramus of uropod 3 (reversal) [19,2]. This sister clade to the *Cerapus* clade is not discussed further.

## Discussion

Much of the evolutionary change in this group of taxa is related to their tube-dwelling behaviour. Examples of morphological changes with obvious functional applications to tube-dwelling are: elongate, robust second antennae; cylindrical body; elongate peraeonite 5 in females; operculum-like peduncle of antenna 1; glands on peraeopods 3 to 4; reduced coxae; reversed distal ends of peraeopods 5 to 7; accessory spines on the dactyli of peraeopods 5 to 7; dorsally ridged urosome; and spines on the dorsum of the telson. Less modified taxa such as *Ericthonius* live in simple nests which cannot be detached and moved around. More highly modified taxa, such as members of the *Cerapus* clade live in complex, movable tubes which they construct from spinning glands in peraeopods 3 and 4 (Lowry, 1981: fig. 9). In the *Siphonoecetes* clade highly modified taxa such as *Concholestes* live in shells, tubes and other independently-made biological structures (Just, 1984: fig. 1).

These evolutionary modifications allow genera with open-ended tubes to reverse positions in the tube, to extend the anterior end of the body out of the tube for feeding or for agonistic behaviour, to shut the tube (in genera with modified peduncles such as *Notopoma*), to crawl and cling with the robust extendible antennae (Barnard *et al.*, 1991). The medially expanded peduncle on antenna 1 functions as an operculum to close the anterior end of the tube. The large carpochele gnathopod of the male is used for agonistic behaviour (pers. obs.), the glands of peraeopod 3 and 4 are used to build the tubes (Giles, 1885; Barnard *et al.*, 1991). The elongation of the female peraeonite 5 increases the volume and hence egg-carrying capacity of the brood chamber. Peraeopods 5–7, uropods and telson are highly modified with spines for gripping the inside of the tube. The dorsal ridges of the urosome form an operculum to close the posterior end of the tube. The huge distoventral hook on the peduncle of uropod 1 in *Cerapus cudjoe* is thought to anchor that species to its tube when it extends its body into the 5 knot currents of Cudjoe Channel (Lowry & Thomas, 1991; Barnard *et al.*, 1991 as *Cerapus* sp. K). The characteristic accessory spines on the dactyli, the reversal of distal ends of peraeopods 5 to 7 and the spines on telson may allow greater purchase on the dorsal surface of the tube.

The relationship of the *Ericthonius* group to other corophioids is not explored in this analysis. But the recurved spines on the rami of uropod 3 indicate a possible relationship to ischyrocerids. Several taxa near the base of the *Ericthonius* group, particularly *Pseudischyrocerus*, do not show strong relationships to other taxa in the clade. *Pseudericthonius* and *Ericthonius* both have strong derived characters in common with the *Cerapus* clade, particularly the carpochele gnathopod 2 of the male, but they also have patches of telsonic spines, a character state shared with the *Siphonoecetes* clade.

The *Cerapus* and *Siphonoecetes* clades are considered

to be sister taxa. They share several equivocal characters which cannot be resolved at this time, particularly accessory spines on the dactyli of pereopod 5 to 7 and a posteriorly directed pereopod 7, which may be considered as derived in a common ancestor or independently derived within each clade.

### Distribution Patterns

Members of the *Cerapus* clade are found world-wide in cold-temperate to tropical seas from the intertidal to 1000 m depth. *Notopoma* is the widest ranging genus. It is most diverse in the southern hemisphere where eight of the 10 shallow-water species occur from tropical to subantarctic waters: French Polynesia (1 species); New Zealand (3 species); Australia (1 species); South Africa (1 species); and the subantarctic islands (2 species). A species reported from Argentina as *Cerapus tubularis* by Alonso (1980) is an undetermined species of *Notopoma* and an undescribed species of *Notopoma* lives in northern Papua New Guinea (Lowry & Berents, in prep.). In the northern hemisphere only 2 species are known: one in the North Sea, north-eastern Atlantic, and one in the Bering Sea, western North Pacific.

*Cerapus* is a shallow-water tropical to temperate genus. In the northern hemisphere it is known from eastern North America (3 species), Japan (1 species), China (1 species) and India (1 species). The record of *C. tubularis* of J.L. Barnard (1962) from southern California is an undescribed species. *Cerapus tubularis* of Nagata (1965) from Japan, may be *C. erae*, but the illustrations are inconclusive. Morino (1976) recorded two forms of *Cerapus tubularis* from Japan, but as he implied, "Form A" is *C. longirostris* Shen, 1936 and "Form B" is *C. erae* Bulycheva, 1952. In the southern hemisphere two species are reported from islands in the South Pacific and two species are also reported from Australia. The record of *C. tubularis* of Hale (1929) from South Australia, is an undescribed species and we know of other undescribed species from this area. The records of *C. tubularis* of Ledoyer (1967, 1969a,b, 1986) from Madagascar etc. and Griffiths (1973, 1974a,b, 1976) from southern Africa represent several undescribed species.

Other genera in the *Cerapus* clade are monotypic or have only a few species with limited distributions.

*Runanga* is found in relatively deep waters of the Tasman Sea and off the east coast of New Zealand. *Bathypoma* is only known from the slope off south-eastern Australia and *Paracerapus* is known only from coastal areas of the Kamchatka Peninsula and the Commander Islands in the Bering Sea.

### Systematics

#### Key to *Erichthonius* Group Genera

1. Pereopods 6–7 similar, much longer than pereopod 5 ..... 2
  - Pereopods 5–6 similar, much shorter than pereopod 7  
(*Siphonoecetes* clade) ..... 8
2. Pereopod 5 propodus inserted at distal end of carpus. Uropod 2 biramous ..... 3
  - Pereopod 5 propodus inserted on posterior concave side of carpus. Uropod 2 uniramous (*Cerapus* clade) ..... 4
3. Uropod 3 uniramous ..... *Erichthonius/Pseuderichthonius*
  - Uropod 3 biramous ..... *Pseudischyrocerus*
4. Antenna 1 without accessory flagellum ..... 5
  - Antenna 1 with vestigial accessory flagellum ..... *Runanga*
5. Antenna 1 peduncle rectangular, not produced anterodistally or medially ..... 6
  - Antenna 1 peduncle subquadrate to rectangular, produced anterodistally and medially ..... 7

6. Peraeopods 5-7 directed posteriorly ..... *Cerapus*
- Peraeopods 5 directed posteriorly, peraeopods 6-7 directed anteriorly ..... *Paracerapus*
7. Gnathopod 2 male subchelate ..... *Bathypoma*
- Gnathopod 2 male carpochele ..... *Notopoma*
8. Uropod 2 biramous ..... 9
- Uropod 2 uniramous ..... 12
- Uropod 2 absent ..... 14
9. Head without anterodorsal depression in rostral area ..... 10
- Head with anterodorsal depression in rostral area ..... *Australoecetes*
10. Antenna 2 flagellum with strong robust setae near distal end ..... 11
- Antenna 2 flagellum with strong robust setae along most of ventral margin ..... *Siphonoecetes (Orientoecetes)*
11. Uropod 1 peduncle with distoventral spur. Uropod 3 ramus, distal margin with row of long pappose setae ..... *Siphonoecetes (Centraloecetes)*
- Uropod 1 peduncle with distoventral corona. Uropod 3 ramus, distal margin with at most a few short, simple setae ..... *Siphonoecetes (Siphonoecetes)*
12. Mandibular palp with 2 articles. Urosomites 1-2 free ..... 13
- Mandibular palp with 1 article. Urosomites 1-2 fused dorsally ..... *Bubocorophium*
13. Head without anterodorsal depression in rostral area. Antenna 2 flagellum with strong robust setae on distal articles. Uropod 1 peduncle with distoventral corona ..... *Borneoecetes*
- Head with anterodorsal depression in rostral area. Antenna 2 flagellum with strong robust setae along much of ventral margin. Uropod 1 peduncle without distoventral corona ..... *Rhinoecetes*
14. Gnathopod 2 simple ..... 15
- Gnathopod 2 strongly subchelate ..... *Concholestes*
15. Uropod 3 without rami ..... 16
- Uropod 3 uniramous ..... *Africoecetes*
16. Peraeopod 7 dactylus small, well developed ..... 17
- Peraeopod 7 dactylus vestigial ..... *Corocubanus*
17. Peraeopods 5-7 dactyli without accessory spines. Telson fused dorsally to urosomite 3, with patches of dorsal spines ..... *Caribboecetes*
- Peraeopods 5-7 dactyli with accessory spines. Telson free, without dorsal spines ..... *Polynesoecetes*

### The *Cerapus* Clade

*Cerapinae* Smith, 1880: 276.

*Cerapiinae* Budnikova, 1989: 55.

**Diagnosis.** *Antenna 1*: slightly more robust than antenna 2. *Antenna 2*: peduncle elongate, slender. *Mandible*: palp large, 3-articulate. *Gnathopod 1*: subchelate in male and female. *Gnathopod 2*: carpocheate (rarely subchelate) in male, subchelate in female. *Peraeopods 3 and 4*: basis inflated, glandular; dactylus not styliform. *Peraeopods 5 to 7*: distal articles reversed so that dactyli are directed posteriorly; dactyli modified with accessory spines (occasionally unmodified). *Peraeopod 5*: coxa enlarged, broad and long anteriorly with small posterior lobe (usually much larger in female), with or without fringe of long setae; merus short, broad, anterior margin produced to nearly or completely over reach carpus, posterior margin produced into a large setose lobe; carpus short, reniform with posterior lobe covered in minute denticles; propodus inserts into concave margin of carpus. *Peraeopods 6 and 7*: similar to each other; peraeopod 7 slightly longer than peraeopod 6, both longer than peraeopod 5. *Urosomites*: free. *Pleopods*: decreasing in size from pleopod 1 to 3 (occasionally not modified). *Pleopods 2 and 3*: reduced inner ramus (occasionally pleopod 3 uniramous or absent). *Uropod 1*: biramous with a corona of spines at distoventral end of peduncle. *Uropods 2 and 3*: uniramous with reduced or rudimentary ramus. *Telson*: short, notched to deeply cleft, each lobe with a dorsal field of recurved spines.

***Cerapus* clade composition.** Five genera: *Cerapus* Say, 1817; *Runanga* J.L. Barnard, 1961; *Paracerapus* Budnikova, 1989; *Notopoma* n.gen. and *Bathypoma* n.gen.

### Generic Diagnoses

#### *Bathypoma* n.gen.

**Diagnosis.** *Antenna 1*: peduncular article 1 with dorsodistal flange partially overlapping article 2 and produced medially to form a operculum; without accessory flagellum. *Mandibles*: left incisor with 5 teeth; left lacinia mobilis with 4 teeth; left accessory setal row with 3 broad robust setae and 3 intermediate plumose setae; right incisor with 5 teeth; right lacinia mobilis with 1 small tooth and a minutely denticulate margin; right accessory setal row with 2 robust setae and 2 plumose setae; mandibular palp short, broad. *Maxilla 1*: outer plates each with 9 setal-teeth. *Gnathopod 2*: subchelate in male and female. *Peraeopods 3 to 7*: dactyli all directed posteriorly. *Peraeopod 4*: merus short, not expanded posteriorly. *Peraeopod 5*: coxa in female larger than in male, without fringe of long setae; dactylus with large unguis and 2 small accessory spines. *Peraeopod 6*: dactylus with large unguis and 2 small accessory spines. *Peraeopod 7*: dactylus with large unguis and 2

small accessory spines. *Pleopod 2*: inner ramus reduced, 1-articulate. *Pleopod 3*: uniramous, 1-articulate ramus. *Uropod 2* with one ramus. *Uropod 3* with one vestigial ramus bearing small recurved spines.

**Type species.** *Bathypoma enigma* n.sp.

**Species composition.** *Bathypoma* is monotypic.

**Etymology.** The name *Bathypoma* is derived from the Greek "poma" for lid and refers to the peduncle of antenna 1 which forms a lid to seal the tube, and "bathys" from the Greek for deep which refers to the depth distribution of the genus.

**Remarks.** *Bathypoma* is unique because the male has a subchelate gnathopod 2. The complex set of characters which makes up gnathopod 2 is considered important because the morphology of the carpus, propodus and dactylus is completely different from that of the carpocheate gnathopod of other males in the *Cerapus* clade. The major muscle mass of the gnathopod occurs in the propodus rather than carpus which indicates that the gnathopod functions in a different way. The overall morphology of the gnathopod does not suggest a neotenic condition, but it is remarkably similar to gnathopods in the genus *Unciola*.

### *Cerapus* Say

*Cerapus* Say, 1817: 49.

*Baracuma* Barnard & Drummond, 1981: 31.

**Diagnosis.** *Antenna 1*: peduncular article 1 with proximoventral swelling; without accessory flagellum. *Mandibles*: left incisor with 6 teeth; left lacinia mobilis with 5 teeth; left accessory setal row with 2–3 broad robust setae and 2–3 intermediate plumose setae; right incisor with 5–6 teeth; right lacinia mobilis with 1 large tooth and a minutely denticulate margin; right accessory setal row with 2 setae and 2 plumose setae; mandibular palp elongate, slender. *Maxilla 1*: outer plates each with 10 setal-teeth. *Gnathopod 2*: carpocheate in male, subchelate in female. *Peraeopods 3 to 7*: dactyli all directed posteriorly. *Peraeopod 4*: merus short, not expanded posteriorly. *Peraeopod 5*: coxa in female larger than in male, without fringe of long setae; dactylus with large unguis and 1–2 small accessory spines. *Peraeopod 6*: dactylus with large unguis and 2 small accessory spines. *Peraeopod 7*: dactylus with large unguis and 1–2 small accessory spines. *Pleopod 2*: inner ramus reduced, 1-articulate. *Pleopod 3*: inner ramus reduced, 1-articulate ramus. *Uropod 2* with one ramus. *Uropod 3* with one vestigial ramus bearing small recurved spines.

**Type species.** *Cerapus tubularis* Say, 1817.

**Species composition.** *Cerapus* currently contains 11 species: *C. alquirtus* (Barnard & Drummond, 1981); *C. benthophilus* Thomas & Heard, 1979; *Cerapus calamicola* (Giles, 1885); *C. cudjoe* Lowry & Thomas, 1991; *C. erae*, Bulycheva, 1952; *C. flindersi* Stebbing, 1888; *C. longirostris* Shen, 1936; *C. micronesicus* Myers, 1995; *C. oceanicus* Lowry, 1985; *C. pacificus* Lowry, 1985; and *C. tubularis* Say, 1817. *Cerapus abditus* Templeton, 1836 is considered to be an unrecognisable species.

**Remarks.** Lowry & Berents (1989) showed that the elongation of peraeonite 5 in the female is not a generic character among the *Cerapus* clade. They maintained *Baracuma* based on the sternal keel. Budnikova (1989) has synonymised *Baracuma* with *Cerapus*. Other possible generic differences between these tightly defined species are: in *C. erae*, *C. longirostris* and *C. oceanicus* the dactyli of peraeopod 5 have two small accessory spines instead of one; and in *C. alquirtus* and *C. oceanicus* there is only one accessory spine on the dactylus of peraeopod 7.

#### *Notopoma* n.gen.

**Diagnosis.** *Antenna 1*: peduncular article 1 with dorsodistal flange partially overlapping article 2 and produced medially to form an operculum; without accessory flagellum. *Mandibles*: left incisor with 4–5 teeth; left lacinia mobilis with 4 teeth; left accessory setal row with 3–4 broad robust setae and 0–3 intermediate plumose setae; right incisor with 4–5 teeth; right lacinia mobilis with 1 large tooth and a minutely denticulate margin; right accessory setal row with 2 robust setae and 2 plumose setae; mandibular palp short, broad. *Maxilla 1*: outer plates each with 7–10 setal-teeth. *Gnathopod 2*: carpochele in male, subchele in female. *Peraeopods 3 to 7*: dactyli all directed posteriorly. *Peraeopod 4*: merus short, not expanded posteriorly. *Peraeopod 5*: coxa in female subequal or larger than in male, without fringe of long setae; dactylus with large unguis and 1–2 small accessory spines. *Peraeopod 6*: dactylus with large unguis and 2 small accessory spines. *Peraeopod 7*: dactylus with large unguis and 1–2 small accessory spines. *Pleopod 2*: inner ramus reduced, 1-articulate or pleopod uniramous. *Pleopod 3*: one reduced 1-articulate ramus or pleopod absent. *Uropod 2* with one ramus. *Uropod 3* with one vestigial ramus bearing small recurved spines.

**Type species.** *Notopoma stoddartae* n.sp.

**Species composition.** *Notopoma* currently contains 10 species: *N. africana* n.sp.; *N. crassicornis* (Bate, 1857); *N. fallohidea* (Lowry, 1981); *N. harfoota* (Lowry, 1981); *N. lukini* (Tzvetkova, 1990); *N. moorea* n.sp.; *N. opposita* (K.H. Barnard, 1931); *N. sismithi* (Stebbing, 1888); *N. stoddartae* n.sp. and *N. stoora* (Lowry, 1981).

**Etymology.** The name *Notopoma* is derived from the Greek “poma” for lid and refers to the peduncle of antenna 1 which forms a lid to seal the tube, and “noto” for southern which refers to the distribution of the genus.

**Remarks.** *Notopoma* differs from *Bathypoma* in having a carpochele gnathopod 2 in the male and from all other genera in the *Cerapus* clade in having an expanded peduncular article 1 on antenna 1. Sars (1894) observed that the peduncular articles function as an operculum in *N. crassicornis*. We have seen this phenomenon a number of times in preserved specimens still in their tubes. Apparently the antenna geniculates strongly between peduncular articles 1 and 2 so that the distal end of the antenna folds back into the tube leaving the dorsal surfaces of the first peduncular articles to form a cap which closes the tube.

#### *Paracerapus* Budnikova

*Paracerapus* Budnikova, 1989: 54.

**Diagnosis.** *Antenna 1*: peduncular article 1 with anterior and posterior margins parallel; without accessory flagellum. *Mandibles*: left and right incisor, lacinia mobilis, accessory setal row and intermediate setae unknown; mandibular palp elongate, slender. *Maxilla 1*: outer plate, setal-teeth unknown. *Gnathopod 2*: carpochele in male, subchele in female. *Peraeopods 3 to 7*: dactyli 3 to 5 directed posteriorly, dactyli 6 to 7 directed anteriorly. *Peraeopod 4*: merus short, expanded posteriorly. *Peraeopod 5*: coxa, female/male size ratios unknown, without fringe of long setae; dactylus with large unguis, small accessory spines apparently absent. *Peraeopod 6*: dactylus with large unguis, small accessory spines apparently absent. *Peraeopod 7*: dactylus with large unguis, small accessory spines apparently absent. *Pleopod 2*: biramous, inner ramus not reduced. *Pleopod 3*: biramous, inner ramus not reduced. *Uropod 2*: possibly biramous, inner ramus vestigial. *Uropod 3* with one vestigial ramus bearing small recurved spines.

**Type species.** *Cerapus polutovi* Gurjanova, 1951.

**Species composition.** *Paracerapus* currently contains 2 species: *Paracerapus comparativus* (Kudrjashov, 1975) and *P. polutovi* (Gurjanova, 1951).

**Remarks.** In *Paracerapus* the dactyli on peraeopods 6 and 7 remain orientated anteriorly, a primitive condition. This, in addition to no accessory spines on the dactyli and an enlarged coxa 2, are the main differences which separate *Paracerapus* from its sister taxon *Cerapus* and other genera in the group.



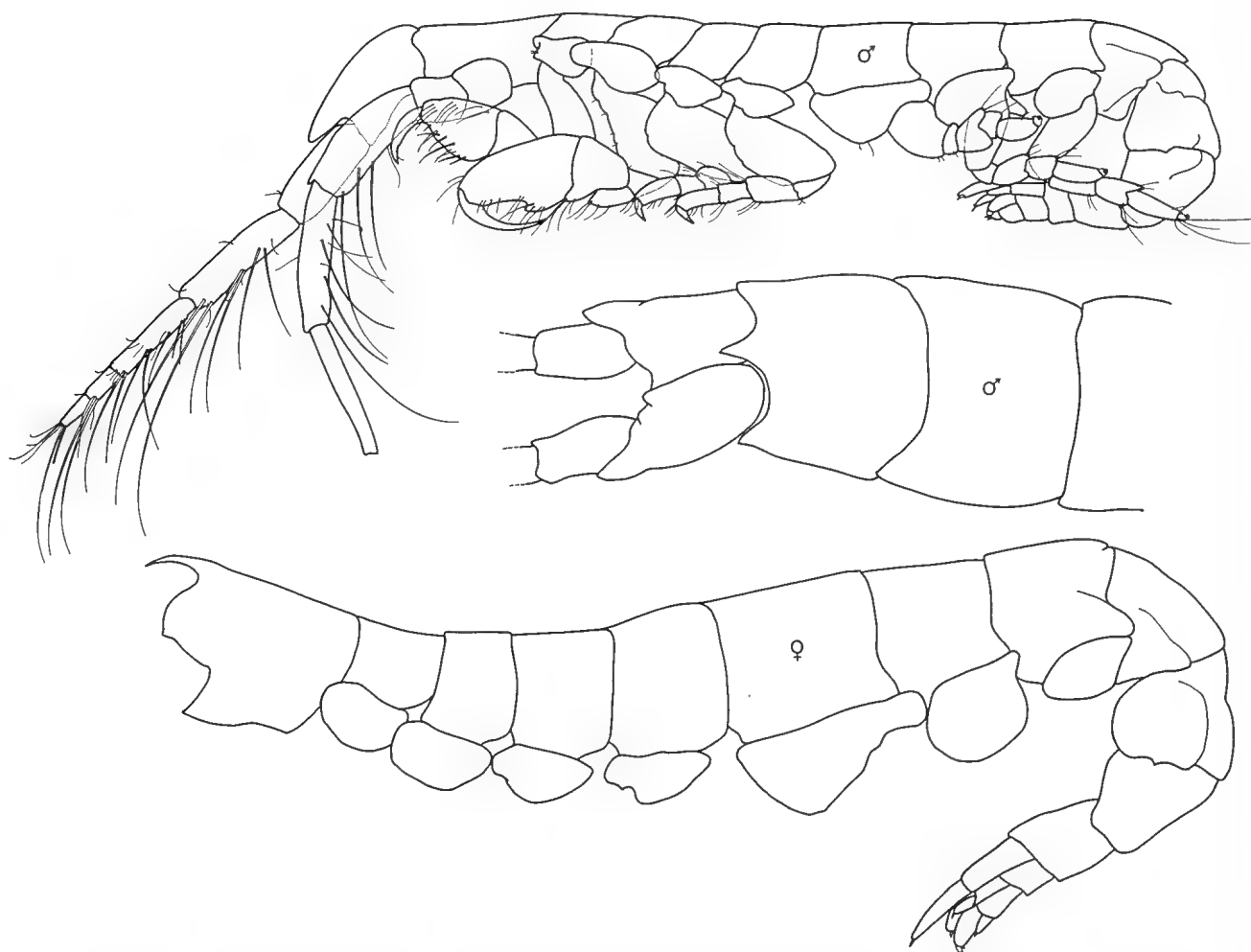


Fig. 4. *Bathypoma enigma* n.sp., lateral view, male holotype, 2.1 mm, NMV J20777; dorsal view, female paratype, 2.6 mm, NMV J20778; east of Freycinet Peninsula, Tasmania.

### *Runanga* J.L. Barnard

*Runanga* J.L. Barnard, 1961: 117.

**Diagnosis.** *Antenna 1*: peduncular article 1 with proximoventral swelling; accessory flagellum scale-like. *Mandibles*: left incisor with 5 teeth; left lacinia mobilis with 5 teeth; left accessory setal row with 3 broad robust setae and 2 intermediate plumose setae; right incisor with 5 teeth; right lacinia mobilis with 1 large tooth and minutely denticulate margin; right accessory setal row with 2 broad robust setae and 3 intermediate plumose setae; mandibular palp long, slender. *Maxilla 1*: outer plates each with 9 setal-teeth. *Gnathopod 2*: carpocheate in male, subcheate in female. *Peraeopods 3 to 7*: dactyli 3 to 5 directed posteriorly, dactyli 6 to 7 directed anteriorly. *Peraeopod 4*: merus long, not expanded posteriorly. *Peraeopod 5*: coxa in female larger than in male, with well-developed fringe of long setae; dactylus with large unguis and 2 small accessory spines.

*Peraeopod 6*: dactylus with large unguis and 2 small accessory spines. *Peraeopod 7*: dactylus with large unguis and 1 small accessory spine. *Pleopod 2*: inner ramus reduced, 1-articulate. *Pleopod 3*: reduced 1-articulate ramus. *Uropod 2* with one ramus. *Uropod 3* with one vestigial ramus bearing small recurved spines.

**Type species.** *Runanga coxalis* J.L. Barnard, 1961.

**Species composition.** *Runanga* contains two species: *R. coxalis* J.L. Barnard, 1961 and *R. wairoa* McCain, 1969.

**Remarks.** Budnikova (1989) pointed out that in addition to the vestigial accessory flagellum, the shape of the head and the telson help to distinguish *Runanga*. Two other characters (elongate merus on peraeopod 4 and strongly setose female coxa 5) also help to distinguish *Runanga* from other genera in the *Cerapus* clade.

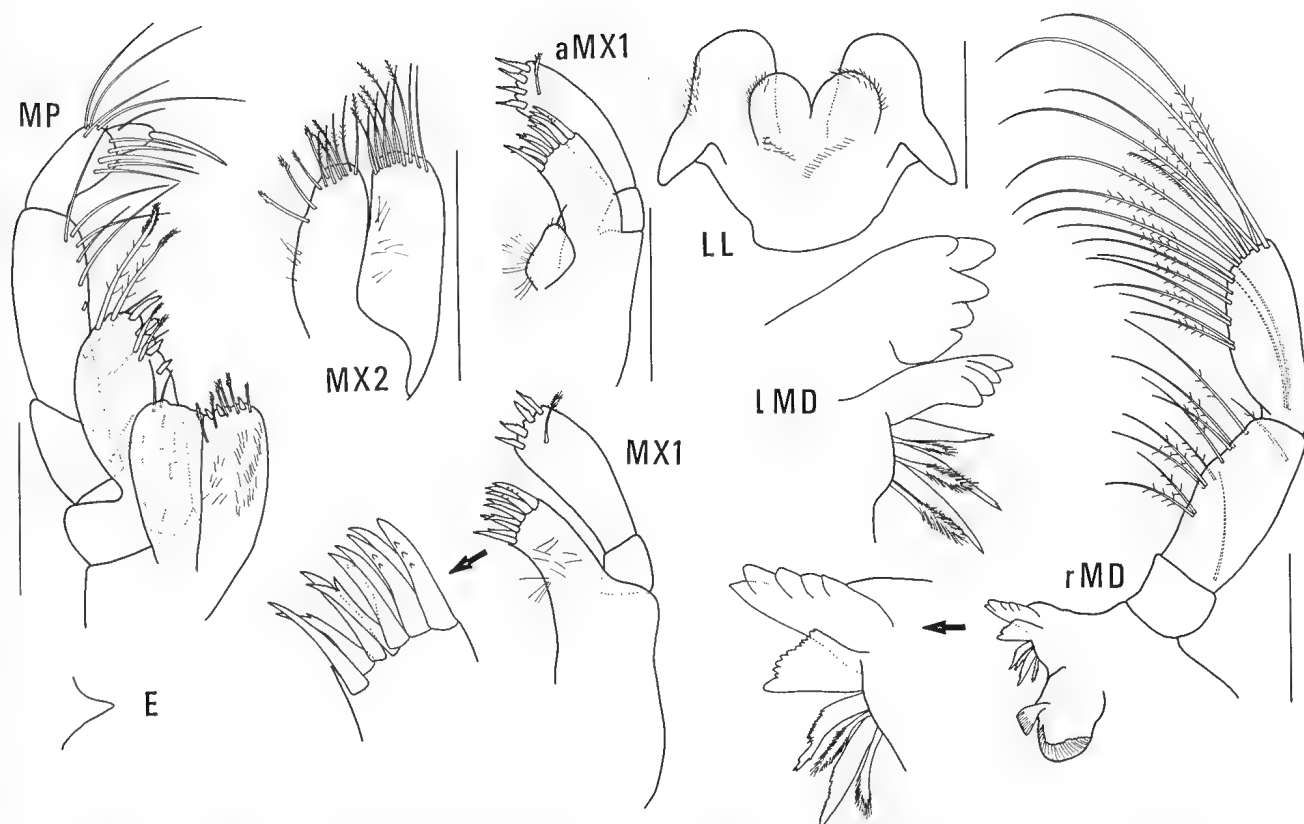


Fig. 5. *Bathypoma enigma* n.sp., male holotype, 2.1 mm, NMV J20777; epistome from male paratype, AM P40434; east of Freycinet Peninsula, Tasmania. Scales represent 0.1 mm.

## Species Descriptions

### *Bathypoma*

#### *Bathypoma enigma* n.sp.

Figs 4–8

**Type data.** HOLOTYPE, male, 2.07 mm, NMV J20777; PARATYPE, female, 2.60 mm, NMV J20778; PARATYPE male, NMV J20779; 31 PARATYPES, NMV J14644; PARATYPE male, 2 mm, AM P40434; 20 PARATYPES, AM P40435; east of Freycinet Peninsula, Tasmania, Australia, 42°2.20'S 148°38.7'E, coarse shelly sand, 800 m, epibenthic sled, M.F. Goman and party on RV *Franklin*, 27 July 1986, SLOPE 45; PARATYPE, NMV J14645, east of Freycinet Peninsula, Tasmania, Australia, 42°0.20'S 148°37.7'E, coarse shelly sand, 720 m, epibenthic sled, M.F. Goman and party on RV *Franklin*, 27 July 1986, SLOPE 46; PARATYPE, NMV J14459, south of Point Hicks, Victoria, Australia, 38°19.60'S 149°24.30'E, rock, rubble, clay, sand, biogenic sediment, 930–951 m, epibenthic sled, M.F. Goman and party on RV *Franklin*, 23 July 1986, SLOPE 33.

**Material described.** Holotype male, 2.07 mm; dimorphic characters based on paratype female, 3.60 mm.

**Description.** *Head:* rostrum short, curved down, apically acute, length  $0.3 \times$  head; lateral cephalic lobe well developed, ventral corner acute, subocular margin deeply recessed, anteroventral corner acute, ventral margin horizontal, posterior margin vertical. *Antenna 1:* long,  $0.5 \times$  body length, without scales; peduncular article 1 produced dorsodistally and dorsomedially, dorsodistal projection  $0.4$  along article 2, length  $0.7 \times$  peduncular article 3; accessory flagellum absent; flagellum long, 3-articulate (female 2), aesthetascs present along ventral margin, article 1 long,  $2.8 \times$  article 2. *Antenna 2:* subequal in length to antenna 1; peduncle without scales; flagellum 4-articulate (female 4), article 1 long,  $2.6 \times$  article 2.

*Epistome and upper lip:* fused, produced, acute. *Mandible:* left incisor with 5 cusps, right incisor with 5 cusps; left lacinia mobilis with 4 cusps, right with one large cusp and minutely serrate margin; left accessory setal row with 3 pappose robust setae, with 3 intermediate plumose setae, right accessory setal row with 2 pappose robust setae, with 2 intermediate plumose setae; molar triturating, molar flake on left and right side, molar seta absent; palp article 2 short, broad, length  $2.1 \times$  breadth,  $1 \times$  article 3, with 1 proximal and 1 distal A2-setae, 5 submarginal A2- and 4 submarginal B2-setae; article 3 clavate, long,  $2.5 \times$  breadth, with 2 proximal A3-setae, 4 submarginal A3- and 4 submarginal B3-setae and 7

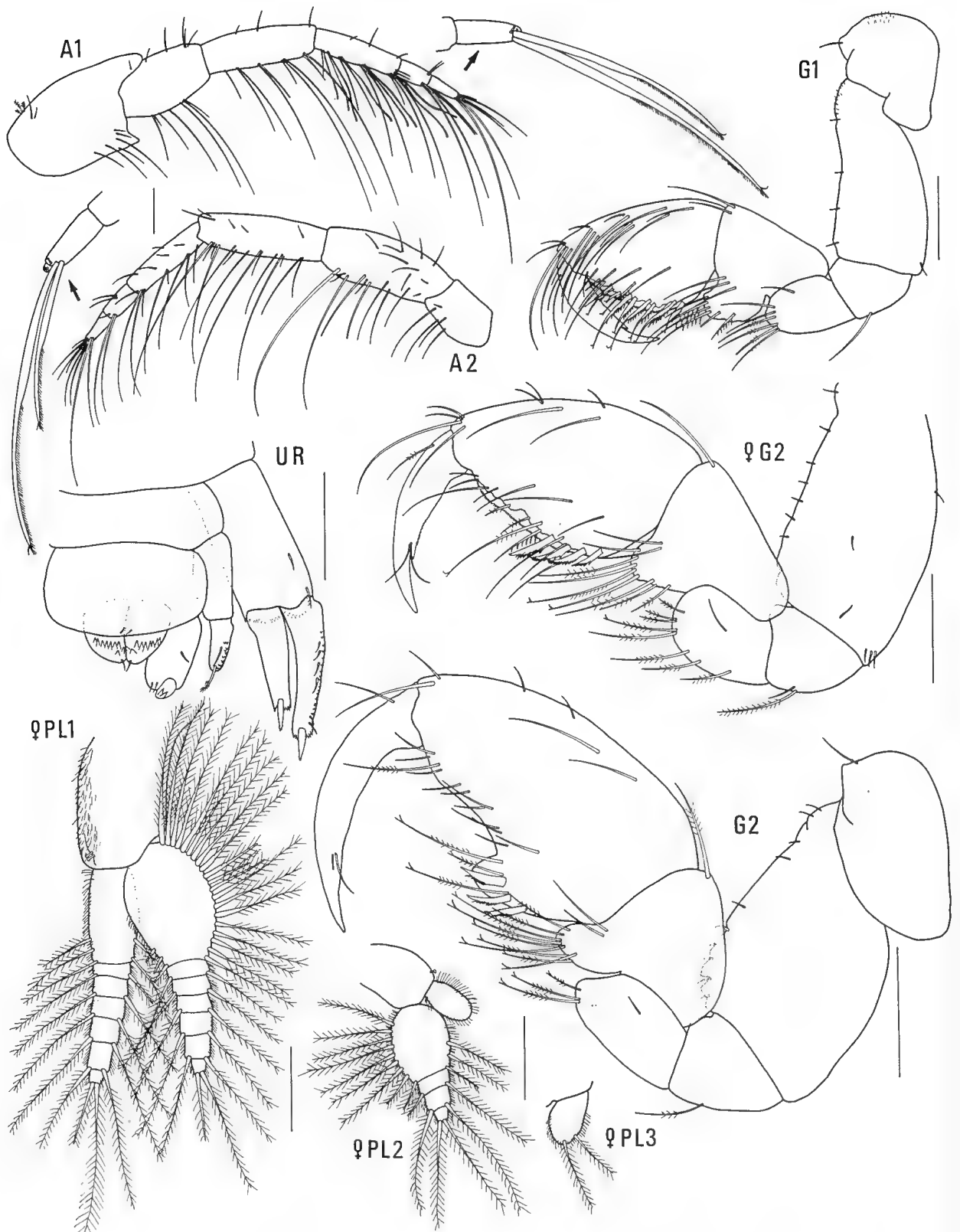


Fig. 6. *Bathypoma enigma* n.sp., male holotype, 2.1 mm, NMV J20777; gnathopod 2 and pleopods from female paratype, 2.6 mm, NMV J20778; east of Freycinet Peninsula, Tasmania. Scales represent 0.1 mm.

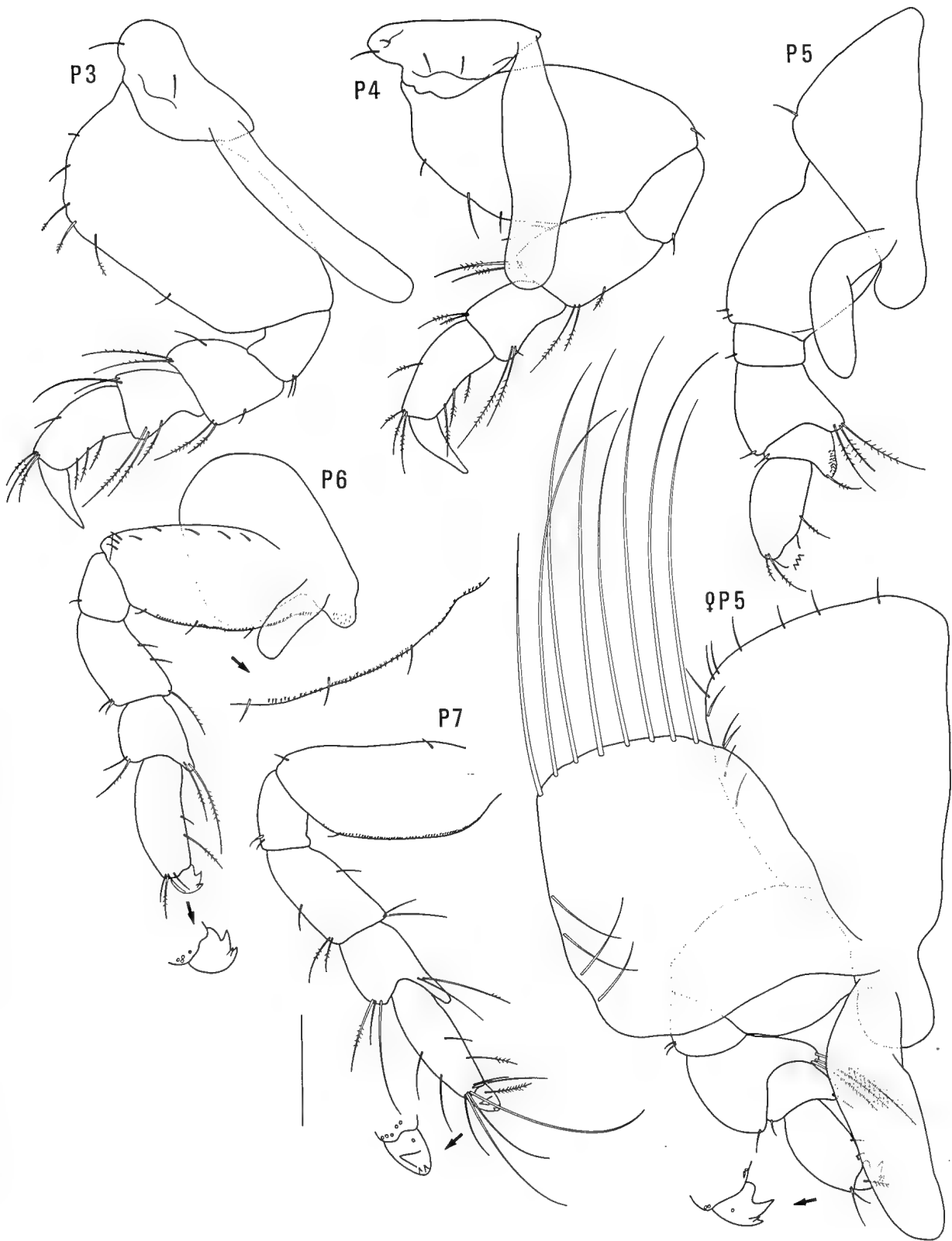


Fig. 7. *Bathypoma enigma* n.sp., male holotype, 2.1 mm, NMV J20777; peraeopod 5 from female paratype, NMV J20778; east of Freycinet Peninsula, Tasmania. Scales represent 0.1 mm.

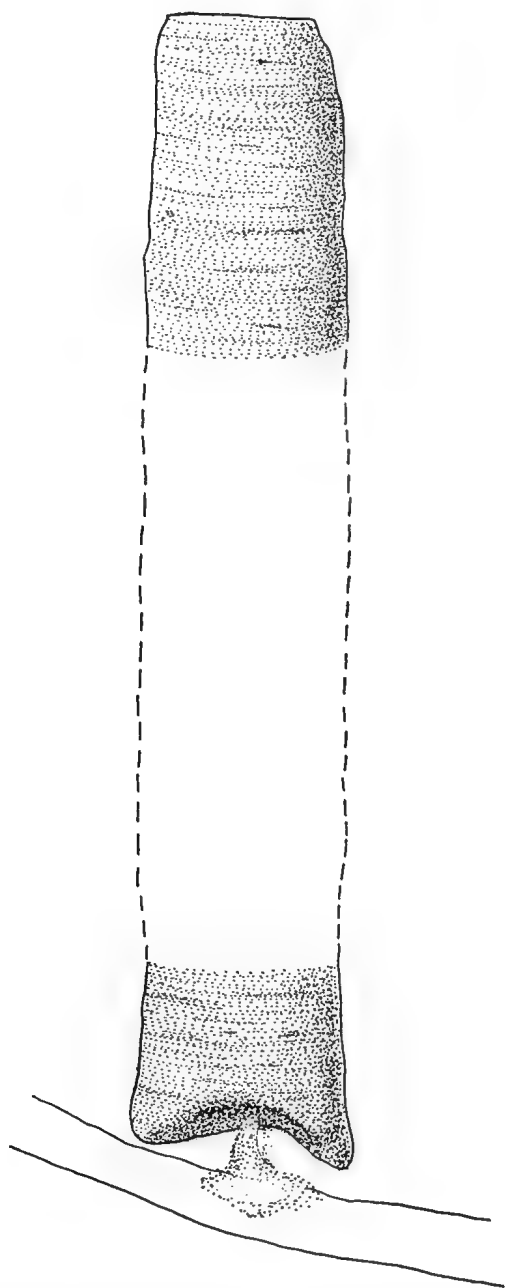


Fig. 8. *Bathypoma enigma* n.sp., tube from paratype of NMV J14644; east of Freycinet Peninsula, Tasmania.

E3-setae terminally. *Maxilla 1*: inner plate small, with 1 simple apical seta; outer plate with 9 setal-teeth; right palp with 3 and left with 3 terminal robust setae, flag seta present on distolateral corner, right palp with 1 and left with 1 subterminal setae. *Maxilla 2*: outer plate slightly broader than inner; inner plate with setae distally along medial margin. *Maxilliped*: inner plate subrectangular with 3 nodular robust setae, without subterminal robust setae on medial corner, oblique setal row with 6 plumose setae; outer plate with 2 apical plumose setae, and 4 apicomедial robust setae; palp

article 2, length  $2.9 \times$  breadth, article 3, length  $2 \times$  breadth.

*Peraeonite 5*: male, length  $1.4 \times$  breadth, female, length  $1.2 \times$  breadth. *Gnathopod 1*: subchelate; coxa not fused to peraeonite 1 in male or female, length  $1.3 \times$  depth, without anteroventral lobe; basis in male with sparse setae along anterior margin, in female with sparse setae along anterior margin, without robust setae along anterior margin; carpus length  $1.1 \times$  depth with setose posterior lobe, anterior margin without setae in male and female; propodus length  $1.6 \times$  depth, with 5 rows of anteromedial setae; palm extremely acute, sparsely setose, with barbed robust setae. *Gnathopod 2*: subchelate in male and female; coxa not fused to peraeonite 2 in male or female, length  $1.7 \times$  depth, without anteroventral lobe; basis short, broad, length  $1.4 \times$  breadth; carpus small, short, compressed, length  $0.8 \times$  breadth, posterior margin without tooth; propodus length  $1.7 \times$  depth; with broad tooth bearing 3 barbed robust setae defining proximal end of palm; dactylus  $0.8 \times$  as long as propodus.

*Peraeopod 3*: coxa not fused to peraeonite 3 in male or female, length  $2 \times$  depth, without anteroventral lobe; basis length  $1.6 \times$  breadth, with inflated anterodorsal corner, with plumose setal group, without denticles along anterior margin; ischium length  $1.6 \times$  breadth; merus without ridges; carpus with 2 simple setae along distal half of anterior margin, with 3 plumose setae along distal half of posterior margin; propodus with 3 plumose setae along posterior margin. *Peraeopod 4*: coxa not fused to peraeonite 4 in male or female, length  $2.2 \times$  depth, without anteroventral lobe; basis length  $1.5 \times$  breadth, without setal group along anterior margin; ischium long, length  $1.8 \times$  breadth; carpus with 2 plumose setae along distal half of anterior margin, with 2 plumose setae along distal half of posterior margin; propodus with 3 plumose setae along posterior margin. *Peraeopod 5*: coxa, length  $2.3 \times$  depth, without patches of small setae; anterior lobe of merus not extending beyond anterior margin of carpus, posterior lobe with 3 plumose setae; propodus with 2 setae along posterior margin, dactylus short, unciniate with two accessory spines. *Peraeopod 6*: coxa with patch of small setae; basis with short, sparse setae anteriorly, with small denticles along posterior margin; merus, length  $1.6 \times$  breadth, without small anterodistal lobe; carpus without anterodistal lobe, with posterodistal lobe, posterodistal corner bearing small setal bunch; propodus, anterodistal corner bearing large setal bunch; dactylus short, unciniate with two accessory spines. *Peraeopod 7*: coxa without posterodorsal lobe, without patch of small setae; basis without denticles along anteroproximal margin, with small denticles along posterior margin; merus, length  $2 \times$  breadth, without small anterodistal lobe, posterodistal corner bearing small setal bunch; carpus without anterodistal lobe, with well-developed posterodistal lobe, anterodistal corner bearing small setal bunch; propodus posterodistal corner bearing small setal bunch, anterodistal corner bearing large setal bunch; dactylus short, unciniate with two accessory spines.

*Oostegites*: from gnathopod 2 to pereopod 5. *Gills*: from pereopod 3 to pereopod 6.

*Pleopods 1 to 3*: decreasing in size. *Pleopod 1*: peduncle with patch of small setae, with 2 small distomedial hooks; rami subequal in length; inner ramus without patch of small setae, 7-articulate; outer ramus, article 1 evenly swollen, 7-articulate. *Pleopod 2*: peduncle without patch of small setae, with 1 small distomedial hook; biramous, inner ramus without patch of small setae, reduced, 1-articulate, length  $0.4 \times$  outer ramus; outer ramus broad, 4-articulate, without patch of small setae. *Pleopod 3*: peduncle without patch of small setae, without distomedial hooks; inner ramus absent. *Uropod 1*: biramous, peduncle with distoventral corona of cuticular teeth, length  $1 \times$  outer ramus, without distoventral spine; outer ramus with lateral row of denticles, with 4 lateral setae, with large apical robust seta; inner ramus length  $0.8 \times$  outer ramus, without setae, with apical robust seta. *Uropod 2*: uniramous, peduncle length  $2.1 \times$  breadth,  $1.7 \times$  ramus; ramus small, with denticles and 1 apical robust seta. *Uropod 3*: uniramous, peduncle length  $1.7 \times$  breadth; ramus with 2 curved spines. *Telson*: length  $0.7 \times$  breadth, cleft  $0.90 \times$  length, each lobe with 9 to 8 anteriorly directed spines in two rows.

**Parasites.** Some specimens of *Bathypoma enigma* had a parasitic copepod attached to the head between antennae 1. These specimens were examined by Grygier (pers. comm.) and identified as males and females of an undescribed species of a nicothoid copepod *Sphaeronella* sp. The specimens are held at the Museum of Victoria, registration NMV J15063.

**Tube.** Composed of annulated fine grains occasionally with detritus and foraminiferans.

**Etymology.** The name *enigma* refers to the subchelate second gnathopod of the species.

**Remarks.** At present this is the sole species in the genus.

**Distribution.** Off south-eastern Australia in 720 to 951 m depth.

### *Notopoma*

#### *Notopoma africana* n.sp.

Figs 9–12

**Type data.** HOLOTYPE, male, 2.48 mm, SAM A15547; PARATYPE, female, 3.56 mm, SAM A41200; 14 PARATYPES, 7 males, 7 females, SAM A41201; 4 PARATYPES, 2 males, 2 females, AM P40663; south-east of St. Lucia, South Africa,  $28^{\circ}31.7'S$   $32^{\circ}34.0'E$ , 680 m, biological dredge, RV *Meiring Naude*, 24 May 1976, stn SM103.

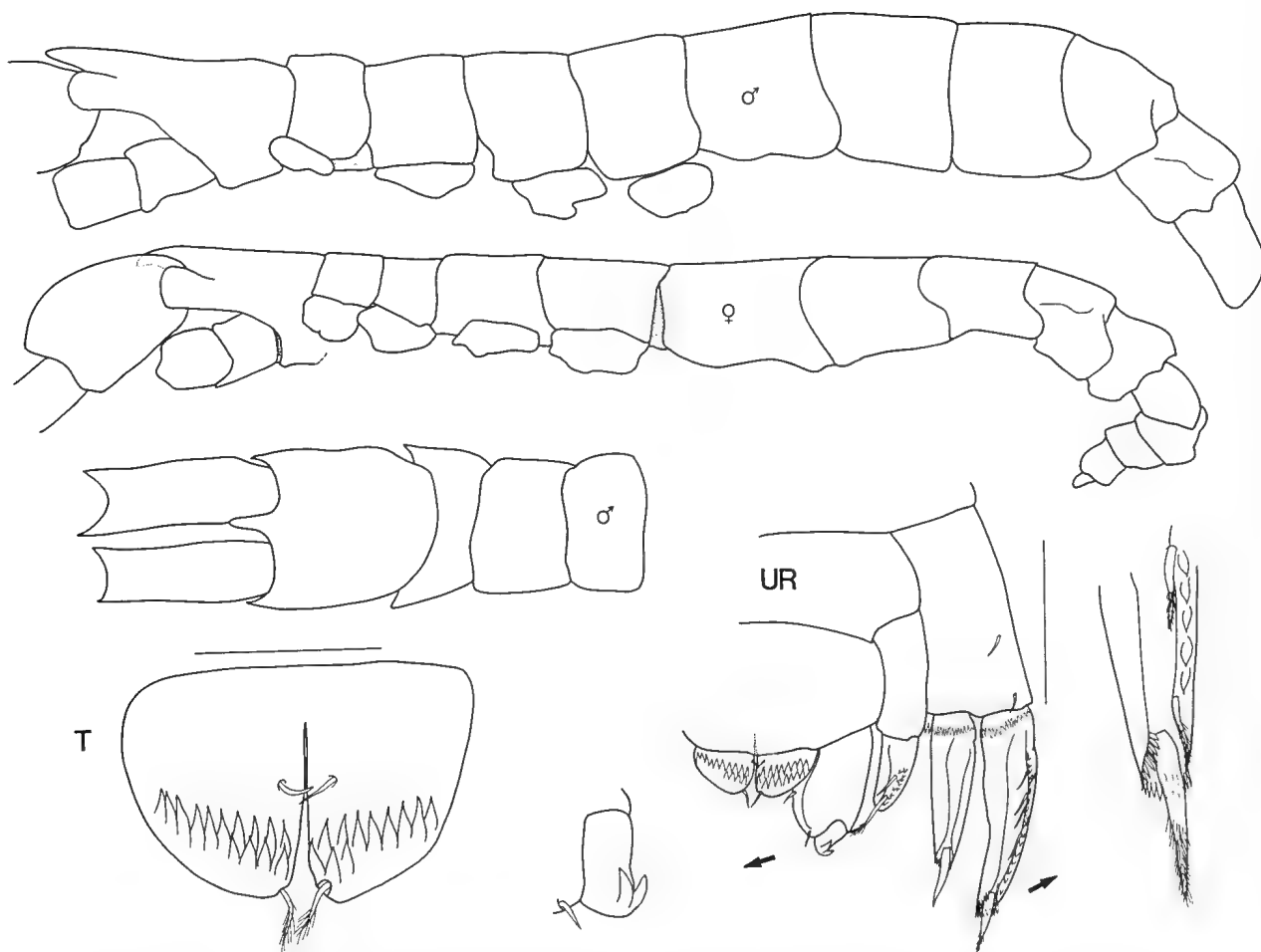
**Material described.** Based on holotype male, 2.48 mm; dimorphic characters based on paratype female, 3.56 mm.

**Diagnosis.** *Antennae*: long, slender. *Mandible*: palp article 2 long, slender, length  $2.8 \times$  breadth, article 3 slender, blade-like. *Maxilla 1*: outer plate with 7 setal-teeth. *Gnathopod 2*: male propodus very broad, slightly curved, length  $1.7 \times$  width. *Pereopod 7*: dactylus with two accessory hoods. *Pleopod 2*: biramous. *Pleopod 3*: small, uniramous.

**Description.** *Head*: rostrum short, curved down, apically acute, length  $0.29 \times$  head; lateral cephalic lobe well developed, ventral corner rounded, subocular margin deeply recessed, anteroventral corner subquadrate, ventral margin horizontal, posterior margin vertical. *Antenna 1*: long,  $0.53 \times$  body length, peduncle with tiny scales; peduncular article 1 produced dorsodistally and dorsomedially, dorsodistal projection  $0.1$  along article 2, length  $1.1 \times$  peduncular article 3; accessory flagellum absent; flagellum long, 4-articulate (female 5), aesthetascs present along ventral margin, article 1 long,  $2 \times$  article 2. *Antenna 2*: subequal in length to antenna 1; peduncle without scales; flagellum 5-articulate (female 6), article 1 long,  $2.3 \times$  article 2.

*Epistome* and *upper lip*: fused, produced, subacute. *Mandible*: left and right incisors each with 5 cusps; left lacinia mobilis with 4 cusps, right with 1 large and 1 small cusp and minutely serrate margin; left accessory setal row with 3 pappose robust setae (damaged on holotype, 3 on paratype male), with 3 intermediate plumose setae (damaged on holotype, 3 on paratype male), right accessory setal row with 2 pappose robust setae, with 2 intermediate plumose setae; molar triturating, molar flake only on right side, molar seta only on left side; palp article 2 long, slender, length  $2.8 \times$  breadth,  $1 \times$  article 3, with 1 proximal and 1 distal A2-setae, 4 submarginal B2-setae and 2 D2-setae along posterior margin; article 3 slender, blade-like, long,  $3.4 \times$  breadth, with 3 proximal A3-setae, 2 submarginal A3- and 2 submarginal B3-setae, and 7 E3-setae. *Maxilla 1*: inner plate small, with 1 simple apical seta; outer plate with 7 setal-teeth; right and left palps each with 3 terminal robust setae, flag seta present on distolateral corner, right and left palps each with 1 subterminal setae. *Maxilla 2*: not known. *Maxilliped*: inner plate subrectangular with 3 nodular robust setae, with 1 subterminal seta on medial corner, oblique setal row with 6 plumose setae; outer plate with 3 apical plumose setae, and 2–3 apicomedial robust setae; palp article 2, length  $2.8 \times$  breadth, article 3, length  $1.7 \times$  breadth.

*Pereopod 5*: male, length  $1 \times$  breadth, female, length  $1.3 \times$  breadth. *Gnathopod 1*: subchelate; coxa not fused to pereopod 1 in male or female, length  $1.2 \times$  depth, without anteroventral lobe; basis in male with sparse setae along anterior margin, in female with sparse setae along anterior margin, without robust setae along anterior margin; carpus length  $1.6 \times$  depth with setose posterior lobe, anterior margin without setae in male and female;



**Fig. 9.** *Notopoma africana* n.sp., lateral view, urosome, telson, male holotype, 2.48 mm, SAM A15547; dorsal view, male paratype, SAM A41201; lateral view, female paratype, SAM A41201, off St. Lucia, South Africa. Scales for urosome and telson represent 0.05 mm.

propodus length  $1.7 \times$  depth, with 4 rows of anteromedial setae; palm extremely acute, sparsely setose, with barbed robust setae. *Gnathopod 2*: carpocheate in male, subchelate in female; coxa not fused to peraeonite 2 in male or female, length  $1.3 \times$  depth, without anteroventral lobe; basis short, broad, length  $1.1 \times$  breadth; carpus massive, long, broad, length  $1.1 \times$  breadth, posterior margin without tooth; palm transverse, palm narrowly excavate, anterodistal tooth small, located distal to articulation with propodus, posterodistal tooth well defined, medium in size, length  $1.4 \times$  width, without robust setae; propodus very broad, slightly curved, length  $1.7 \times$  width, without tooth on posterior margin, with tooth on posterodistal corner; dactylus, length  $0.74 \times$  propodus.

*Peraeopod 3*: coxa not fused to peraeonite 3 in male or female, length  $3.3 \times$  depth, without anteroventral lobe; basis length  $1.8 \times$  breadth, without inflated anterodorsal corner, with plumose setal group, without denticles along anterior margin; ischium length  $1 \times$  breadth; merus without ridges; carpus with 1 plumose seta along distal half of anterior margin, with 3 plumose setae along distal half of posterior margin; propodus

with 3 plumose setae along posterior margin. *Peraeopod 4*: coxa not fused to peraeonite 4 in male or female, length  $1.9 \times$  depth, without anteroventral lobe; basis length  $1.7 \times$  breadth, without setal group along anterior margin; ischium short, length  $0.9 \times$  breadth; carpus with 1 plumose setae along distal half of anterior margin, with 2 plumose setae along distal half of posterior margin; propodus with 3 plumose setae along posterior margin. *Peraeopod 5*: coxa, length  $1.7 \times$  depth, without patches of small setae; anterior lobe of merus not extending beyond anterior margin of carpus, posterior lobe with 3 plumose setae; propodus with 1 seta along posterior margin, dactylus short, uncinuate with two accessory spines. *Peraeopod 6*: coxa without patch of small setae; basis with short, sparse setae anteriorly, without small denticles along posterodistal margin; merus, length  $1.6 \times$  breadth, without small anterodistal lobe; carpus without anterodistal lobe, with posterodistal lobe, posterodistal corner bearing small setal bunch; propodus, anterodistal corner bearing large setal bunch; dactylus short, uncinuate with two accessory spines. *Peraeopod 7*: coxa tapering and truncated posteriorly, without patch of small setae; basis without denticles





**Fig. 10.** *Notopoma africana* n.sp., male holotype, 2.48 mm, SAM A15547; off St. Lucia, South Africa. Scales represent 0.1 mm.

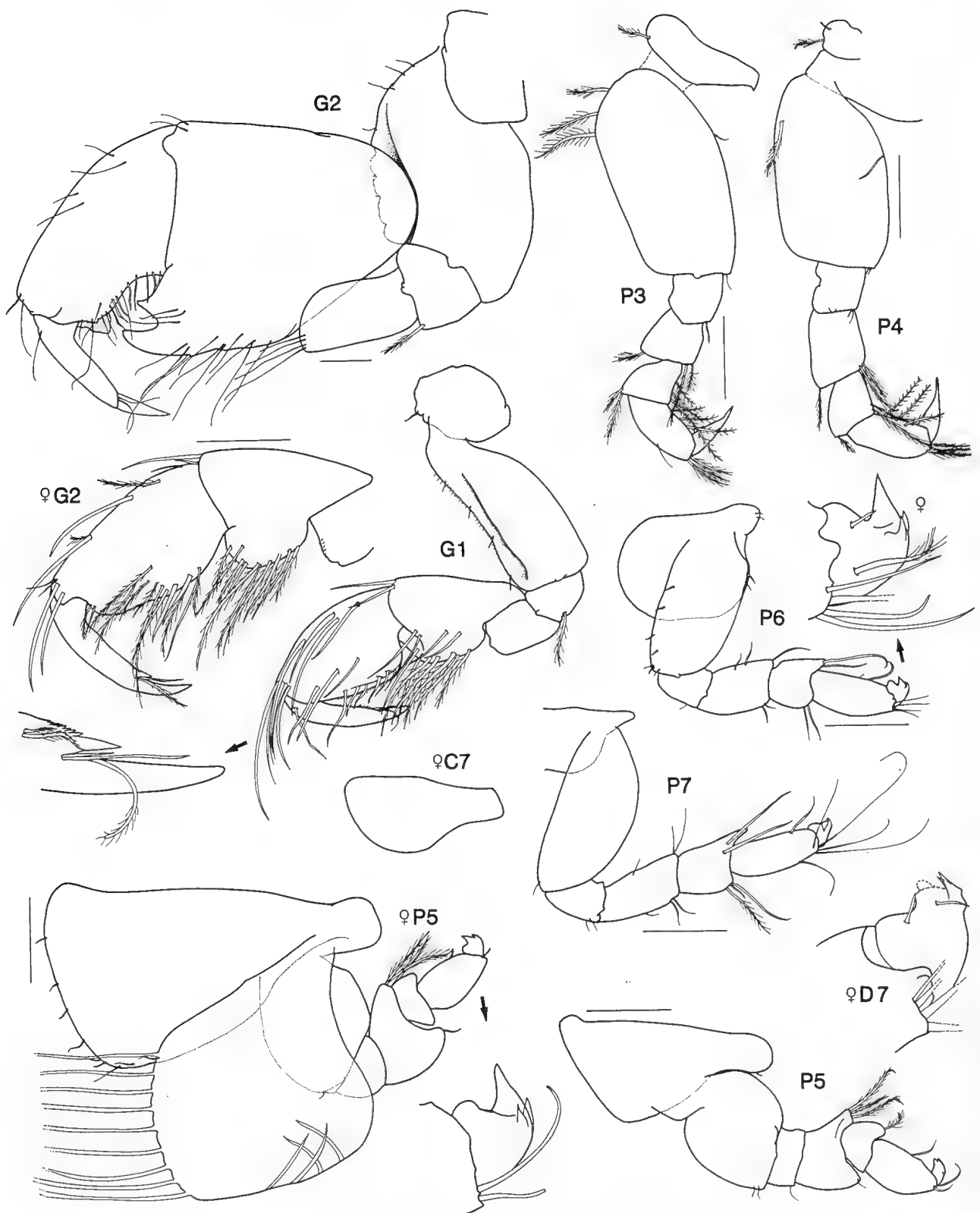


Fig. 11. *Notopoma africana* n.sp., male holotype, 2.48 mm, SAM A15547; female paratype, SAM A41200; off St. Lucia, South Africa. Scales represent 0.1 mm.

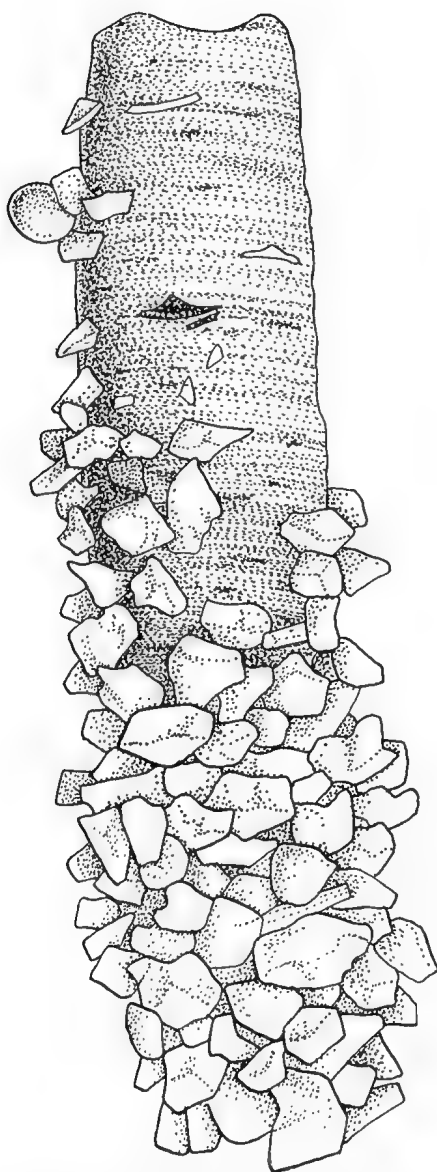


Fig. 12. *Notopoma africana* n.sp., tube; off St. Lucia, South Africa.

along anteroproximal margin, without small denticles along posterodistal margin; merus, length  $1.7 \times$  breadth, without small anterodistal lobe, posterodistal corner bearing small setal bunch; carpus without anterodistal lobe, with well-developed posterodistal lobe, anterodistal corner bearing small setal bunch; propodus, posterodistal corner without setal bunch, anterodistal corner bearing large setal bunch; dactylus short, uncinuate with two accessory spines.

*Oostegites*: from gnathopod 2 to pereopod 5. *Gills*: from pereopod 3 to pereopod 6.

*Pleopods 1 to 3*: decreasing in size. *Pleopod 1*: peduncle without patch of small setae, with 2 small distomedial hooks; rami subequal in length; inner ramus without patch of small setae, 6-articulate; outer ramus,

article 1 with straight medial margin, 7-articulate. *Pleopod 2*: peduncle without patch of small setae, with 1 small distomedial hook; biramous, ramus without patch of small setae, inner ramus reduced, 1-articulate, length  $0.5 \times$  outer ramus; outer ramus broad, 3-articulate, without patch of small setae. *Pleopod 3*: peduncle without patch of small setae, with 1 small distomedial hook; inner ramus absent. *Uropod 1*: biramous, peduncle with distoventral corona of cuticular teeth, length  $1 \times$  outer ramus, without distoventral spine; outer ramus with lateral row of denticles, with 4 lateral setae, with large apical robust seta; inner ramus length  $0.8 \times$  outer ramus, without setae, with apical robust seta. *Uropod 2*: uniramous, peduncle length  $2.6 \times$  breadth,  $1.7 \times$  ramus; ramus small, with denticles and 1 apical robust seta. *Uropod 3*: uniramous, peduncle length  $1.5 \times$  breadth; ramus with 2 curved spines. *Telson*: length  $0.7 \times$  breadth, cleft  $0.74 \times$  length, each lobe with 14 to 11 anteriorly directed spines in two rows.

**Tube.** Composed of annulated fine detrital grains with large grains of sand or shell grit at one end.

**Etymology.** The name *africana* refers to the distribution of the species.

**Remarks.** *Notopoma africana* shows similarities to *N. fallohidea* in the long slender antenna and deeply cleft telson, but in *N. africana* the mandibular palp is more slender, the outer plate of maxilla 1 has 10 setal-teeth, article 2 of the maxillipedal palp is longer and pleopod 3 is uniramous.

*Notopoma sismithi* also has a long slender first antenna and the maxillipedal palp article 2 is long and slender as in *N. africana*. But *N. sismithi* has a shorter, broader mandibular palp and the shape of the palm in the male second gnathopod is convex.

**Distribution.** South-east of St Lucia, South Africa, Indian Ocean in 680 m depth.

#### *Notopoma moorea* n.sp.

Figs 13–15

**Type data.** HOLOTYPE, male, 1.80 mm, AM P42279; PARATYPE, male, AM P42280; PARATYPE, female, 2.0 mm, AM P42281; coral slope of exposed fringing reef near Afareaitu, Moorea, Society Islands, French Polynesia,  $17^{\circ}33.7'S$   $149^{\circ}56.5'W$ , dead corals, 1–2 m, H.G. Müller, 26 March 1988.

**Material described.** Based on holotype male, 1.8 mm; dimorphic characters based on paratype female, 2.0 mm.

**Diagnosis.** *Antennae*: short, robust. *Mandible*: palp article 2 short, broad, length  $1.8 \times$  breadth, article 3 clavate. *Maxilla 1*: outer plate with 9 setal-teeth.

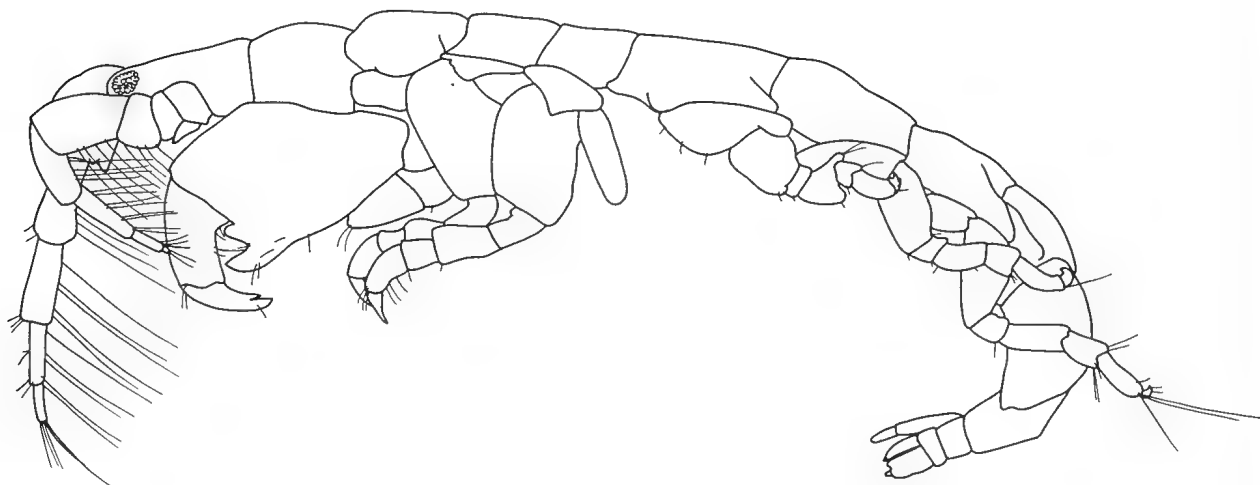


Fig. 13. *Notopoma moorea* n.sp., lateral view, male holotype; 1.8 mm, AM P42279; Moorea, Society Islands, French Polynesia.

*Gnathopod 2*: male propodus very broad, slightly curved, length  $2.1 \times$  width. *Peraeopod 7*: dactylus with one accessory spine. *Pleopod 2*: biramous, inner ramus vestigial. *Pleopod 3*: small, uniramous.

**Description.** *Head*: rostrum short, straight, apically rounded, length  $0.2 \times$  head; lateral cephalic lobe well developed, ventral corner rounded, subocular margin deeply recessed, anteroventral corner subquadrate, ventral margin horizontal, posterior margin vertical. *Antenna 1*: short,  $0.28 \times$  body length, without scales; peduncular article 1 produced dorsodistally and dorsomedially, dorsodistal projection  $0.5$  along article 2, length  $1.9 \times$  peduncular article 3; accessory flagellum absent; flagellum short, 2-articulate (female 2), aesthetascs present along ventral margin, article 1 long,  $2.1 \times$  article 2. *Antenna 2*: subequal in length to antenna 1; peduncle without scales; flagellum 3-articulate (female 3), article 1 long,  $2.6 \times$  article 2.

*Epistome and upper lip*: fused, produced, subacute. *Mandible*: left incisor with 4 cusps, right incisor with 5 cusps; left lacinia mobilis with 4 cusps, right with one large cusp and minutely serrate margin; left accessory setal row with 3 pappose robust setae, without intermediate plumose setae, right accessory setal row with 2 pappose robust setae, with 2 intermediate plumose setae; molar triturating, palp article 2 short, broad, length  $1.8 \times$  breadth,  $1 \times$  article 3. Without proximal A2-setae. Without distal A2-setae, with 4 posterior submarginal A2-setae, with 4 B2-posterior submarginal setae, without D2-setae; article 3 clavate, long,  $2.3 \times$  breadth, without proximal A3-setae, without distal A3-setae, without submarginal A3-setae, with 3 posterior submarginal B3-setae, with 7 D3-setae, and 3 E3-setae. *Maxilla 1*: inner plate small, without setae; outer plate with 9 setal-teeth; right palp with 5 terminal robust setae, without subterminal setae. *Maxilla 2*: unknown. *Maxilliped*: unknown.

*Peraeonite 1*: without lateral keel in male. *Peraeonite 2*: without sternal keel in male. *Peraeonite 5*: male, length  $2 \times$  breadth, female, length  $2.1 \times$  breadth. *Gnathopod 1*: subchelate; coxa not fused to peraeonite 1 in male or female, length  $1.9 \times$  depth, without anteroventral lobe; basis in male with sparse setae along anterior margin, in female with sparse setae along anterior margin, without robust setae along anterior margin; carpus length  $1 \times$  depth with setose posterior lobe, anterior margin without setae in male and female; propodus length  $1.4 \times$  depth, with 5 rows of anteromedial setae; palm acute, sparsely setose, with barbed robust setae. *Gnathopod 2*: carpochele in male, subchelate in female; coxa not fused to peraeonite 2 in male or female, length  $1.8 \times$  depth, without anteroventral lobe; basis short, broad, length  $1 \times$  breadth; carpus massive, long, broad, length  $1.1 \times$  breadth, posterior margin without tooth; palm slightly obtuse, palm narrowly excavate, anterodistal tooth large, located near articulation with propodus, posterodistal tooth well defined, medium in size, length  $1.5 \times$  width, without robust setae; propodus very broad, slightly curved, length  $2.1 \times$  width, without tooth on posterior margin, with smooth posterodistal corner; dactylus, length  $0.5 \times$  propodus.

*Peraeopod 3*: coxa not fused to peraeonite 3 in male or female, length  $3 \times$  depth, without anteroventral lobe; basis length  $1.5 \times$  breadth, with inflated anterodorsal corner, with setae along anterior margin, without denticles along anterior margin; ischium length  $1.5 \times$  breadth; merus without ridges; carpus with 1 simple seta along distal half of anterior margin, without setae along posterior margin; propodus with 3 plumose setae along posterior margin. *Peraeopod 4*: coxa not fused to peraeonite 4 in male or female, length  $1.8 \times$  depth, without anteroventral lobe; basis length  $1.5 \times$  breadth, without setal group along anterior margin; ischium long, length  $1.5 \times$  breadth; carpus with 2 simple setae along distal half of anterior margin, with 2 simple setae along posterior

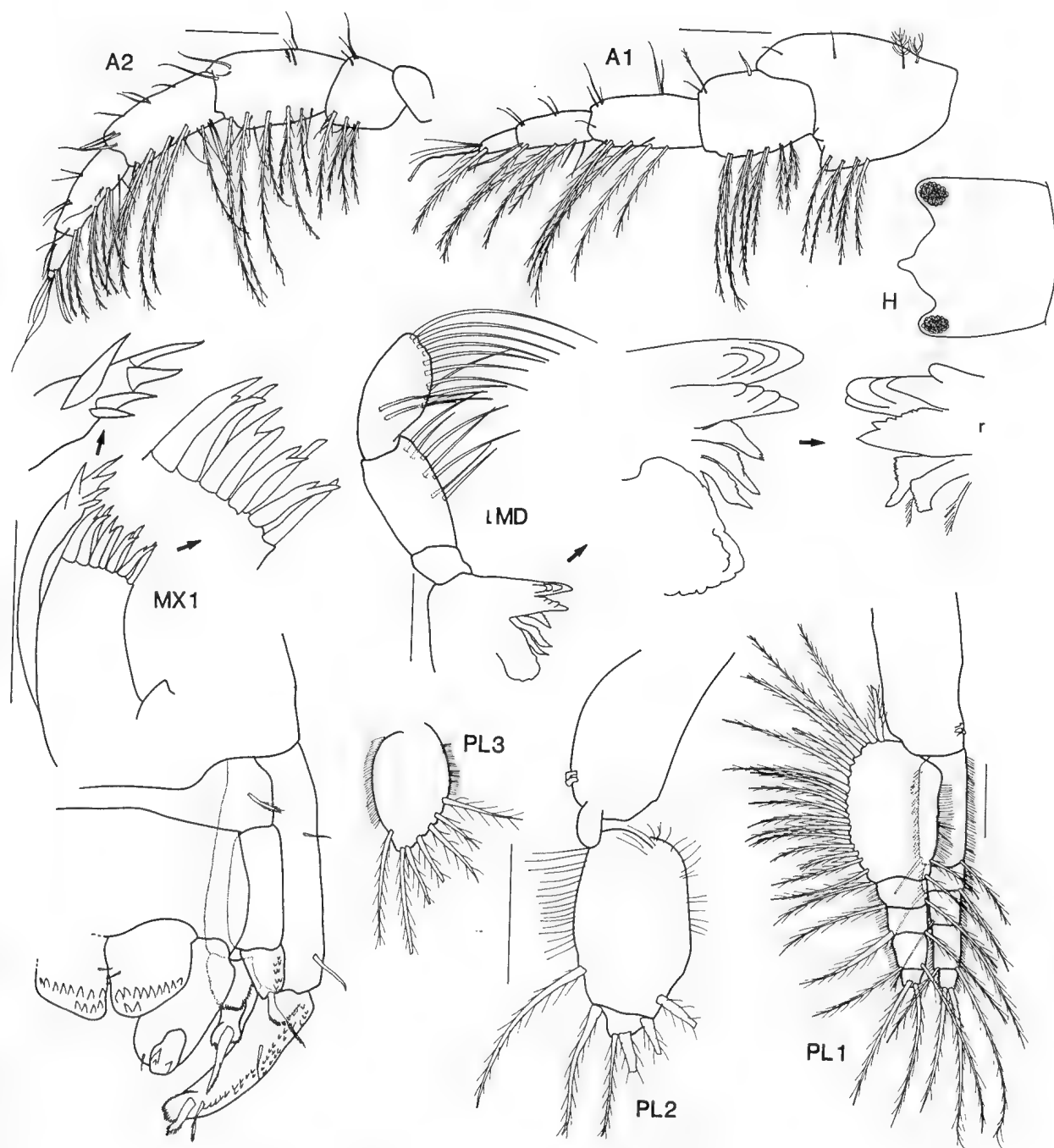
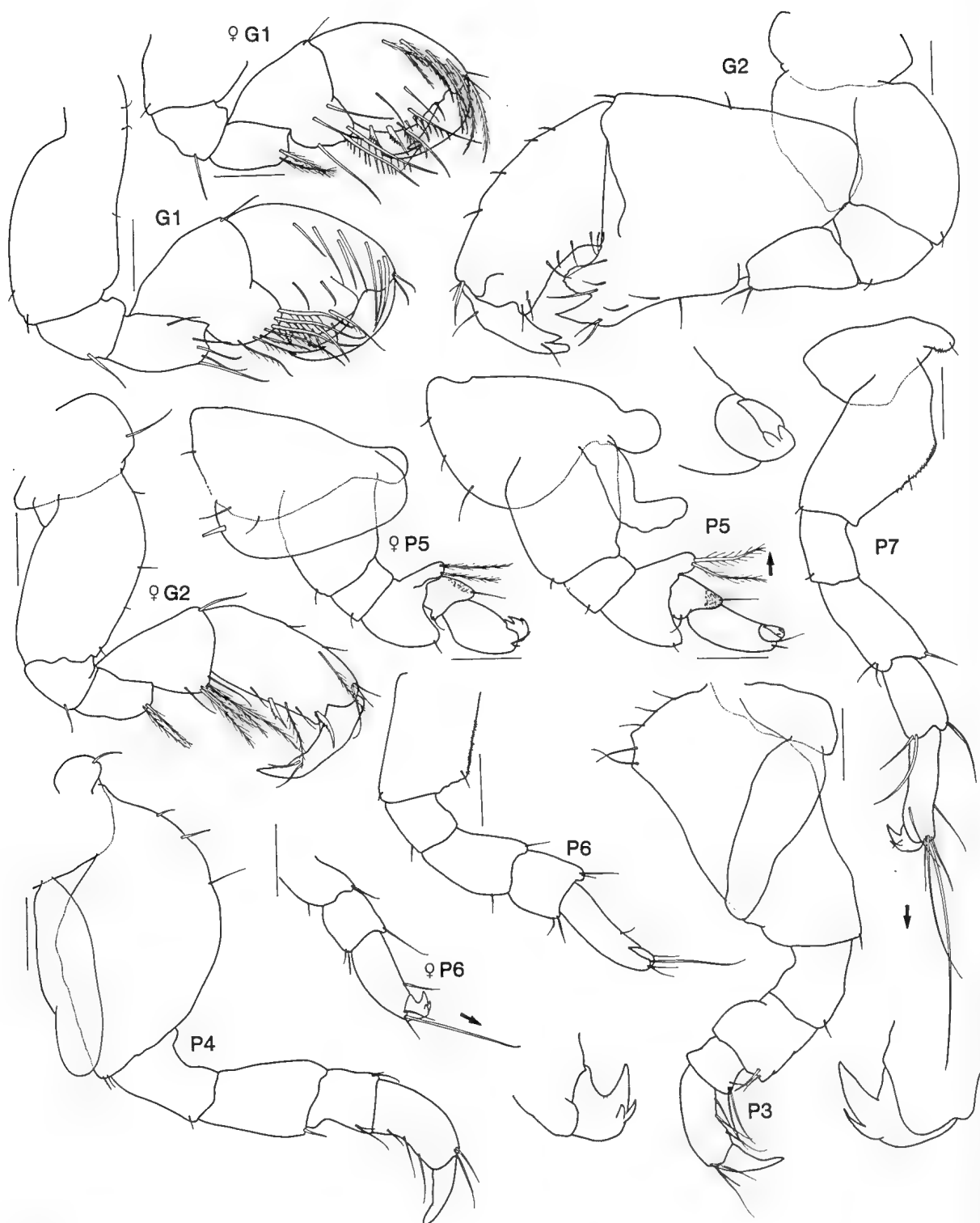


Fig. 14. *Notopoma moorea* n.sp., male holotype, 1.8 mm, AM P42279; Moorea, Society Islands, French Polynesia. Scales for A1-2 represent 0.1 mm, scales for MD, MX1, PL1-3 represent 0.05 mm.

margin; propodus with 3 simple setae along posterior margin. *Peraeopod 5*: coxa, length  $1.8 \times$  depth, without patches of small setae; anterior lobe of merus not extending beyond anterior margin of carpus, posterior lobe with 2 plumose setae; propodus without setae along posterior margin, dactylus short, uncinat with two accessory spines. *Peraeopod 6*: coxa without setal fringe ventrally, without patch of small setae; basis without anterior setae. With small denticles along posterodistal margin. Merus, length  $1.4 \times$

breadth, without small anterodistal lobe; carpus without anterodistal lobe, without posterodistal lobe, posterodistal corner bearing small setal bunch; propodus, anterodistal corner bearing small setal bunch; dactylus short, uncinat with two accessory spines. *Peraeopod 7*: coxa with posterodorsal lobe, with patch of small setae; basis without denticles along anteroproximal margin, with small denticles along posterodistal margin; merus, length  $1.7 \times$  breadth, without small anterodistal lobe, posterodistal



**Fig. 15.** *Notopoma moorea* n.sp., male holotype, 1.8 mm, AM P42279; female, 2.0 mm, AM P42281; Moorea, Society Islands, French Polynesia. Scales represent 0.1 mm.

corner bearing small setal bunch; carpus without anterodistal lobe, without posterodistal lobe, anterodistal corner bearing small setal bunch; propodus posterodistal corner bearing small bunch of long setae,

anterodistal corner bearing small seta; dactylus short, uncinuate with one accessory spine.

*Oostegites*: from gnathopod 2 to pereopod 5. *Gills*: from pereopod 3 to pereopod 6.

*Pleopods 1 to 3*: decreasing in size. *Pleopod 1*: peduncle without patch of small setae, with 2 small distomedial hooks; rami subequal in length; inner ramus without patch of small setae, 5-articulate; outer ramus, article 1 with straight medial margin, 5-articulate. *Pleopod 2*: peduncle without patch of small setae, with 2 small distomedial hooks; biramous, inner ramus reduced, without patch of small setae, 1-articulate, length  $0.2 \times$  outer ramus; outer ramus broad, 2-articulate, without patch of small setae. *Pleopod 3*: peduncle unknown; inner ramus unknown; outer ramus broad, 1-articulate, without patch of small setae. *Uropod 1*: biramous, peduncle with distoventral corona of cuticular teeth, length  $1.3 \times$  outer ramus, without distoventral spine; rami with distoventral corona of cuticular teeth outer ramus with lateral row of denticles, with 1 medial seta, with large apical robust seta; inner ramus length  $0.5 \times$  outer ramus, without setae, with apical robust seta. *Uropod 2*: uniramous, peduncle length  $2.1 \times$  breadth,  $2.5 \times$  ramus; ramus small, with denticles and 1 apical robust seta. *Uropod 3*: uniramous peduncle length  $2.3 \times$  breadth; ramus with 3 curved spines. *Telson*: length  $0.6 \times$  breadth, cleft  $0.5 \times$  length, each lobe with 12 to 11 anteriorly directed spines in two rows.

**Tube.** Probably without a tube.

**Etymology.** The name *moorea* refers to the type locality of the species.

**Distribution.** Afareaitu, Moorea, Society Islands, French Polynesia, in depths of 1 to 2 m.

*Notopoma stoddartae* n.sp.

Figs 16–18

**Type data.** HOLOTYPE, male, 2.74 mm, AM P40436; PARATYPE, male, 2.30 mm, AM P40437; PARATYPE, female, 2.15 mm, AM P40438; 49 PARATYPES, AM P40470; 20 PARATYPES, USNM 274136; outer reef edge near the wreck of the *Runic*, Middleton Reef, Tasman Sea,  $29^{\circ}27.4'S$   $159^{\circ}03.7'E$ , rubble, algae, coarse sediment, 12 m, J.K. Lowry & R.T. Springthorpe, 5 December 1987, site 8.1; 30 PARATYPES, AM P40471, outer reef slope near the wreck of the *Fuku Maru*, Middleton Reef, Tasman Sea  $29^{\circ}29.1'S$   $159^{\circ}08.1'E$ , coral rubble, 12 m, Australian Museum Party, 7 December 1987, site 20; 6 PARATYPES, BMNH 1995.716–721, outer slope west of the wreck of the *Yoshin Maru Iwaki*, Elizabeth Reef, Tasman Sea,  $29^{\circ}57.2'S$   $159^{\circ}01.2'E$ .

**Material described.** Based on holotype male, 2.74 mm; dimorphic characters based on paratype female, 2.15 mm.

**Diagnosis.** *Antennae*: short, robust. *Mandible*: palp article 2 short, broad, length  $1.6 \times$  breadth, article 3 broad, clavate. *Maxilla 1*: outer plate with

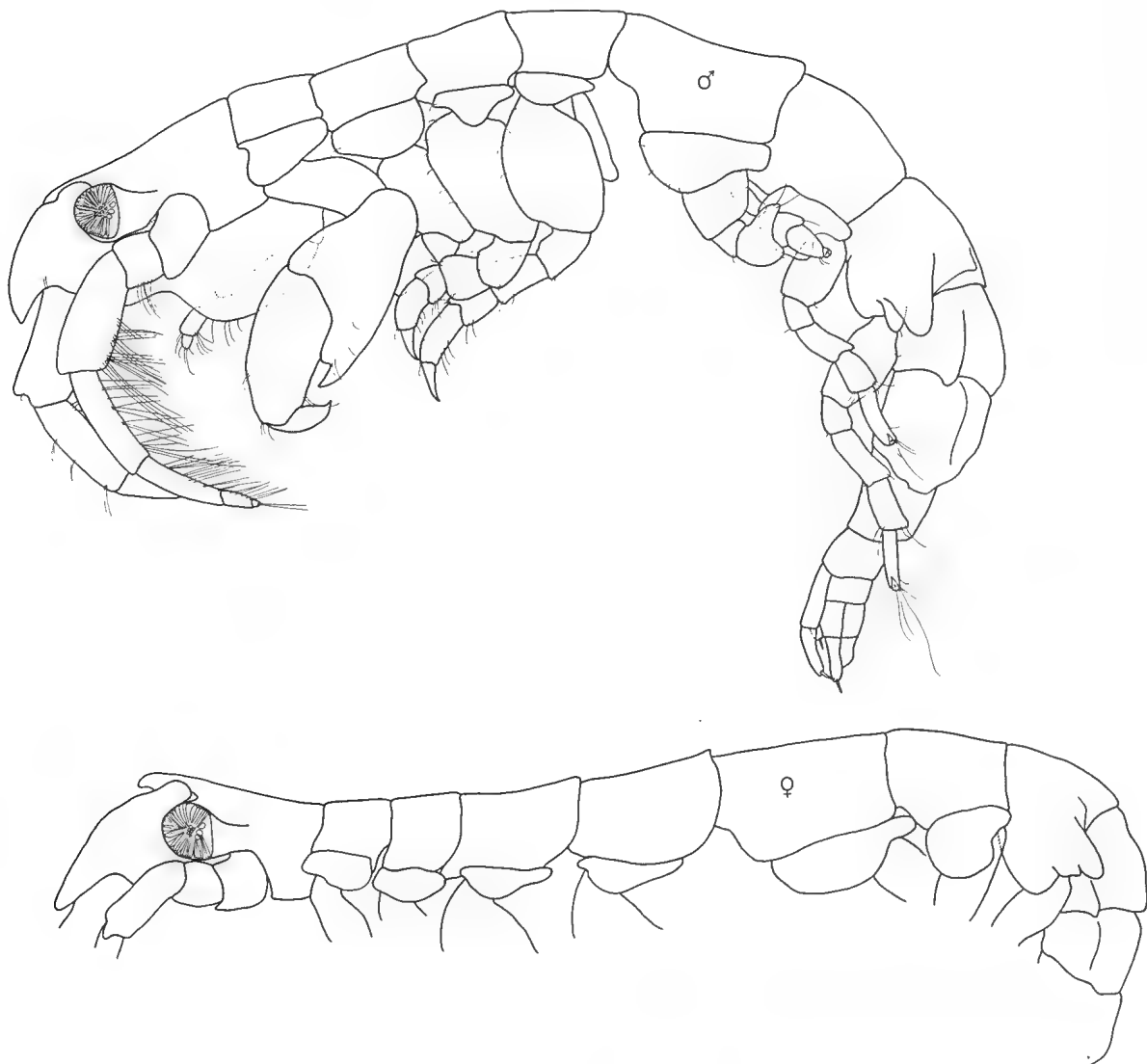
9 setal-teeth. *Gnathopod 2*: male propodus broad, curved, length  $3.2 \times$  width. *Peraeopod 7*: dactylus with one accessory spine. *Pleopod 2*: uniramous. *Pleopod 3*: absent.

**Description.** *Head*: rostrum short, straight, apically rounded, length  $0.37 \times$  head; lateral cephalic lobe well developed, ventral corner rounded, subocular margin deeply recessed, anteroventral corner subquadrate, ventral margin horizontal, posterior margin vertical. *Antenna 1*: short,  $0.3 \times$  body length, without scales; peduncular article 1 produced dorsodistally and dorsomedially, dorsodistal projection  $0.4$  along article 2, length  $1.2 \times$  peduncular article 3; accessory flagellum absent; flagellum short, 2-articulate (female 2), aesthetascs absent, article 1 long,  $2.1 \times$  article 2. *Antenna 2*: subequal in length to antenna 1; peduncle without scales; flagellum 3-articulate (female 3), article 1 long,  $2.8 \times$  article 2.

*Epistome and upper lip*: fused, produced, subacute. *Mandible*: left incisor with 4 cusps, right incisor with 4 cusps; left lacinia mobilis with 4 cusps, right with 2 large cusps and minutely serrate margin; left accessory setal row with 2 pappose robust setae, without intermediate plumose setae, right accessory setal row with 2 pappose robust setae, without intermediate plumose setae; molar triturating, molar flake on left and right side, molar seta absent; palp article 2 short, broad, length  $1.6 \times$  breadth,  $0.9 \times$  article 3, with 1 proximal and 1 distal A2-setae, 5 submarginal A2-setae, and 4 submarginal B2-setae; article 3 clavate, short,  $2.3 \times$  breadth, with 3 proximal A3-setae, 5 submarginal A3- and 5 submarginal B3-setae and 6 E3-setae. *Maxilla 1*: inner plate small, with 1 simple apical seta; outer plate with 9 setal-teeth; right and left palps each with 3 terminal robust setae, flag seta present on distolateral corner, right and left palps each with 2 subterminal setae. *Maxilla 2*: outer plate broader than inner; inner plate with setae distally along medial margin. *Maxilliped*: inner plate subrectangular with 3 nodular robust setae, without subterminal robust setae on medial corner, oblique setal row with 7 plumose setae; outer plate with 2 apical plumose setae, and 4 apicomедial robust setae; palp article 2, length  $2.1 \times$  breadth, article 3, length  $1.7 \times$  breadth.

*Peraeonite 5*: male, length  $1.8 \times$  breadth, female, length  $1.8 \times$  breadth. *Gnathopod 1*: subchelate; coxa not fused to peraeonite 1 in male or female, length  $1.5 \times$  depth, with short anteroventral lobe; basis in male with sparse setae along anterior margin, in female with sparse setae along anterior margin, with robust setae along anterior margin; carpus length subequal  $\times$  depth with setose posterior lobe, anterior margin without setae in male and female; propodus length  $1.3 \times$  depth, with 6 rows of anteromedial setae; palm acute, sparsely setose, with barbed robust setae. *Gnathopod 2*: carpochelelate in male, subchelate in female; coxa not fused to peraeonite 2 in male or female, length  $1.6 \times$  depth, without anteroventral lobe; basis short, broad, length  $1 \times$  breadth; carpus massive, long, broad, length  $1.1 \times$  breadth, posterior margin without tooth; palm transverse, broadly excavate, anterodistal tooth large, located near





**Fig. 16.** *Notopoma stoddartae* n.sp., lateral view, male holotype, 2.3 mm, AM P40436; dorsal view, female paratype, AM P40438; Middleton Reef, Tasman Sea.

articulation with propodus, posterodistal tooth well defined, medium in size, length  $1 \times$  width, without robust setae; propodus broad, curved, length  $3.2 \times$  width, without tooth on posterior margin, with rugose posterodistal corner; dactylus, length  $0.4 \times$  propodus.

*Peraeopod 3*: coxa not fused to pereonite 3 in male or female, length  $2.3 \times$  depth, with small anteroventral lobe; basis length  $1.1 \times$  breadth, with inflated anterodorsal corner, without setal group, with denticles along anterior margin; ischium length  $1.8 \times$  breadth; merus without ridges; carpus with 1 simple seta along distal half of anterior margin, with 2 plumose setae along distal half of posterior margin; propodus with 3 plumose setae along posterior margin.

*Peraeopod 4*: coxa not fused to pereonite 4 in male or female, length  $2.4 \times$  depth, without anteroventral lobe; basis length  $1.2 \times$  breadth, without setal group along anterior margin; ischium long, length  $1.8 \times$  breadth; carpus with 2 simple setae along distal half

of anterior margin, with 1 plumose seta along distal half of posterior margin; propodus with 3 simple setae along posterior margin. *Peraeopod 5*: coxa, length  $1.8 \times$  depth, without patches of small setae; anterior lobe of merus not extending beyond anterior margin of carpus, posterior lobe with 2 plumose setae; propodus with 1 seta along posterior margin, dactylus short, uncinatate with two accessory spines. *Peraeopod 6*: coxa without patch of small setae; basis without anterior setae, with small denticles along posterodistal margin; merus, length  $1.7 \times$  breadth, without small anterodistal lobe; carpus without anterodistal lobe, without posterodistal lobe, posterodistal corner bearing small setal bunch; propodus, anterodistal corner bearing large setal bunch; dactylus short, uncinatate with two accessory spines. *Peraeopod 7*: coxa with posterodorsal lobe, without patch of small setae; basis without denticles along anteroproximal margin, with small denticles along posterodistal margin; merus, length  $2.3 \times$  breadth,



Fig. 17. *Notopoma stoddartae* n.sp., male holotype, 2.3 mm, AM P40436; Middleton Reef, Tasman Sea. Scales for antennae represent 0.1 mm, the remainder represent 0.05 mm.

without small anterodistal lobe, posterodistal corner bearing small setal bunch; carpus without anterodistal lobe, with small posterodistal lobe, anterodistal corner

bearing small setal bunch; propodus posterodistal corner bearing small setal bunch, anterodistal corner bearing large setal bunch; dactylus short, uncinat

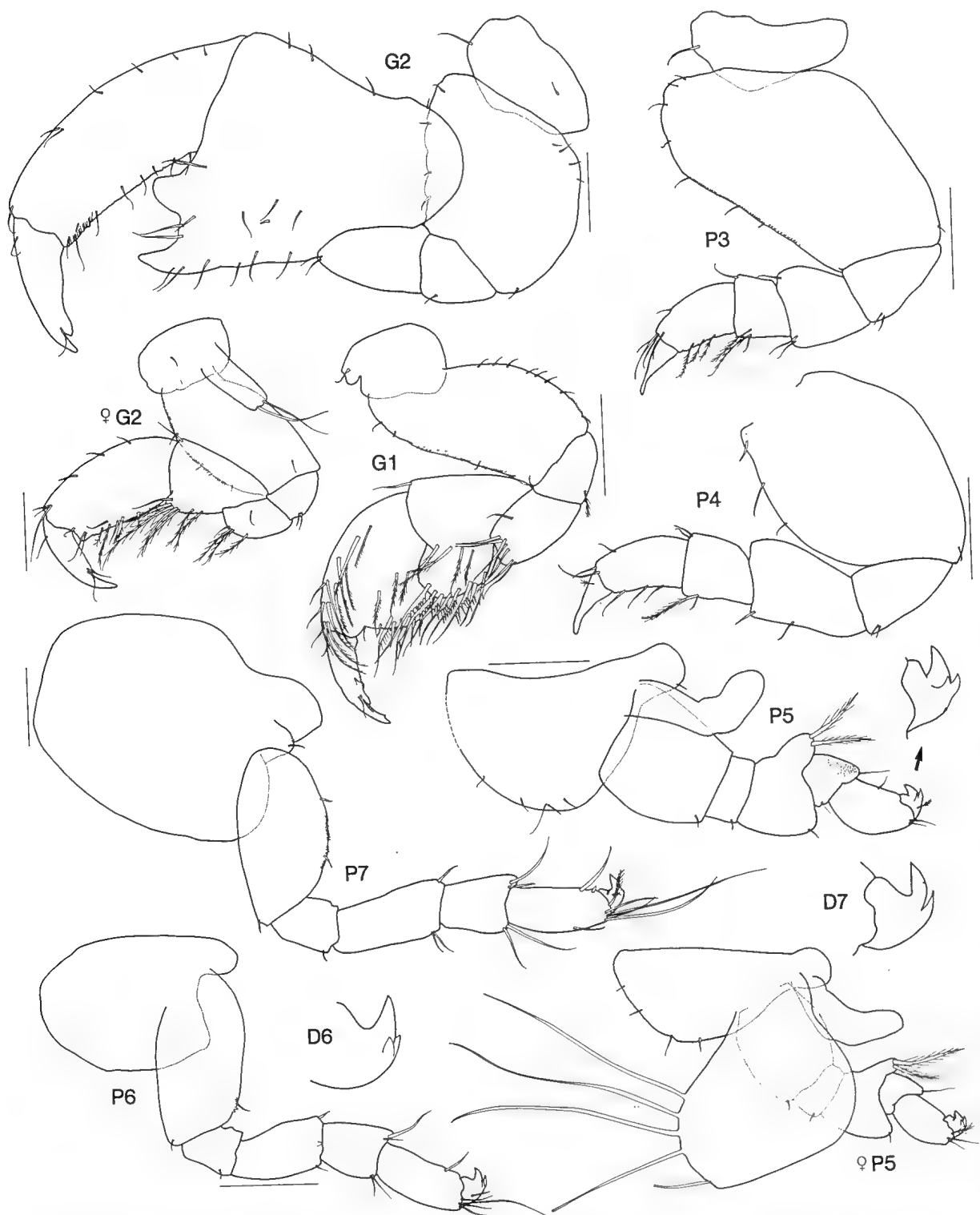


Fig. 18. *Notopoma stoddartae* n.sp., male holotype, 2.3 mm, AM P40436; gnathopod 1, peraeopod 5 plus dactylus from female paratype, AM P40438; Middleton Reef, Tasman Sea. Scales represent 0.1 mm.

with one accessory spine.

*Oostegites*: from gnathopod 2 to peraeopod 5. *Gills*: from peraeopod 3 to peraeopod 6.

*Pleopods 1 to 3*: pleopod 1 larger than 2, pleopod 3 absent. *Pleopod 1*: peduncle without patch of small setae, with 2 small distomedial hooks; rami subequal

in length; inner ramus without patch of small setae, 4-articulate; outer ramus, article 1 with straight medial margin, 5-articulate. *Pleopod 2*: peduncle without patch of small setae, without distomedial hooks; uniramous, ramus without patch of small setae. *Uropod 1*: biramous, peduncle with distoventral corona of cuticular teeth,

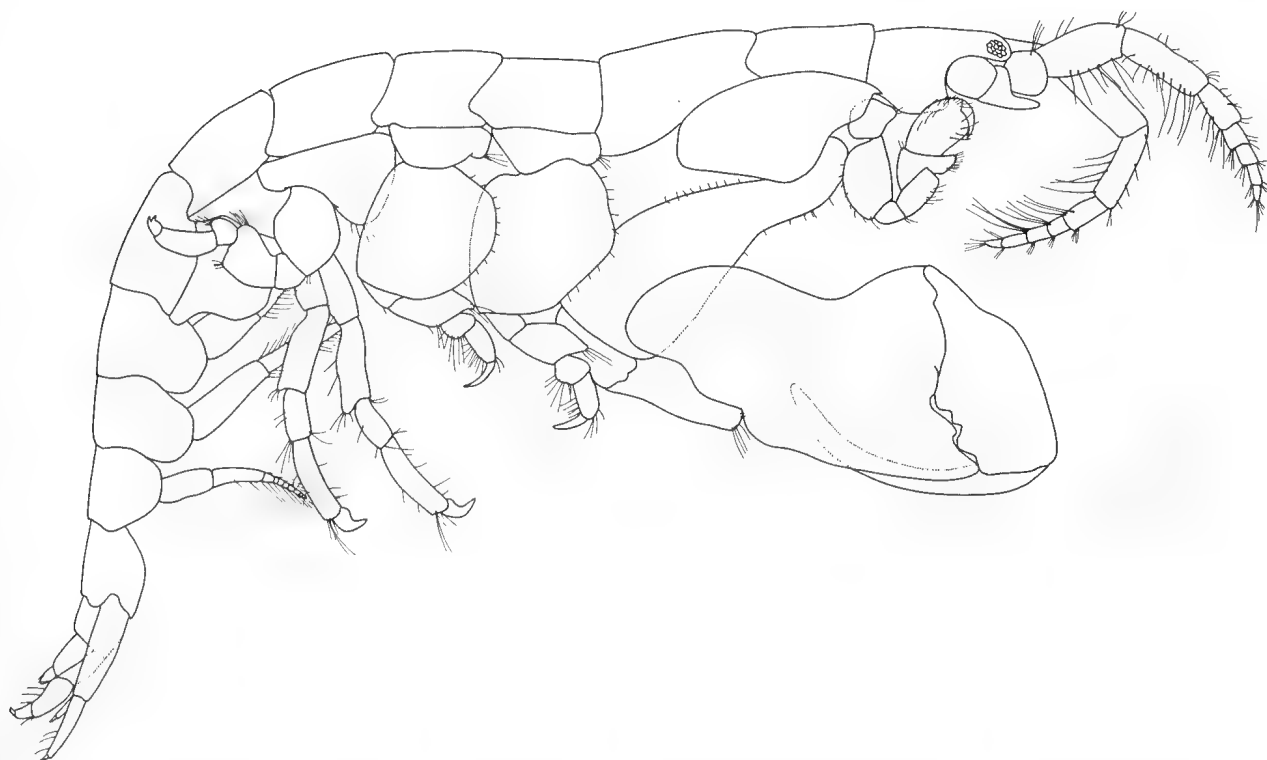


Fig. 19. *Paracerapus polutovi* Gurjanova, 1951, lateral view, male paratype, 6.2 mm, AM P41691; East Kamchatka, Bering Sea.

length  $1.1 \times$  outer ramus, without distoventral spine; outer ramus with lateral row of denticles, with 2 medial setae, with large apical robust seta; inner ramus length  $0.3 \times$  outer ramus, without setae, with apical robust seta. *Uropod* 2: uniramous, peduncle length  $1.7 \times$  breadth,  $1.3 \times$  ramus; ramus small, with denticles and 1 apical robust seta. *Uropod* 3: uniramous, peduncle length  $1.7 \times$  breadth; ramus with 5 curved spines. *Telson*: length  $0.5 \times$  breadth, cleft to base, each lobe with 12 to 12 anteriorly directed spines in two rows.

**Tube.** Composed of detritus and sand grains.

**Etymology.** This species is named in recognition of the contribution of Helen Stoddart to amphipod systematics.

**Remarks.** *Notopoma stoddartae* shows similarities to species with short antenna 1 and with short mandibular palp (*N. harfoota*, *N. opposita* and *N. stoora*). It is very similar to *N. stoora*, but *N. stoora* differs in the carpus of pereopods 6 and 7 which is posterodistally lobate, the presence of pleopod 3, and it is brightly coloured. *Notopoma opposita* has well-developed posterodistal lobes on the carpus of pereopods 6 and 7, and two accessory spines on the dactylus of pereopod 7. *Notopoma harfoota* has a very distinctive female first gnathopod which distinguishes it from other species in the genus.

**Distribution.** Elizabeth and Middleton Reefs, Tasman Sea in depths of 12 to 21 m.

## *Paracerapus*

### *Paracerapus polutovi* (Gurjanova)

Figs 19–21

*Cerapus polutovi* Gurjanova, 1951: 946, fig. 658.

*Paracerapus polutovi*. Budnikova, 1989: 54.

? *Cerapus comparativus* Kudrjashov, 1975: 364, fig. 1.

? *Paracerapus comparativus*. Budnikova, 1989: 54.

**Type data.** PARATYPES, male, 6.2 mm, AM P41691, female, 6.1 mm, male, AM P41692, East Kamchatka, Bering Sea, 20–29 m, 13 July 1934, stn 539.

**Material described.** Based on paratype male, 6.2 mm; dimorphic characters based on paratype female, 6.1 mm.

**Diagnosis.** *Antennae*: short, slender. *Mandible*: palp article 2 article 2 short, broad, length  $1.8 \times$  breadth, article 3 broad, clavate. *Maxilla* 1: outer plate with 10 setal-teeth. *Gnathopod* 2: male propodus broad, slightly curved, length  $2.4 \times$  width. *Pereopod* 7: dactylus with row of accessory spines. *Pleopod* 2: biramous. *Pleopod* 3: biramous.

**Description:** *Head*: rostrum very short, straight, apically rounded; lateral cephalic lobe well developed, ventral

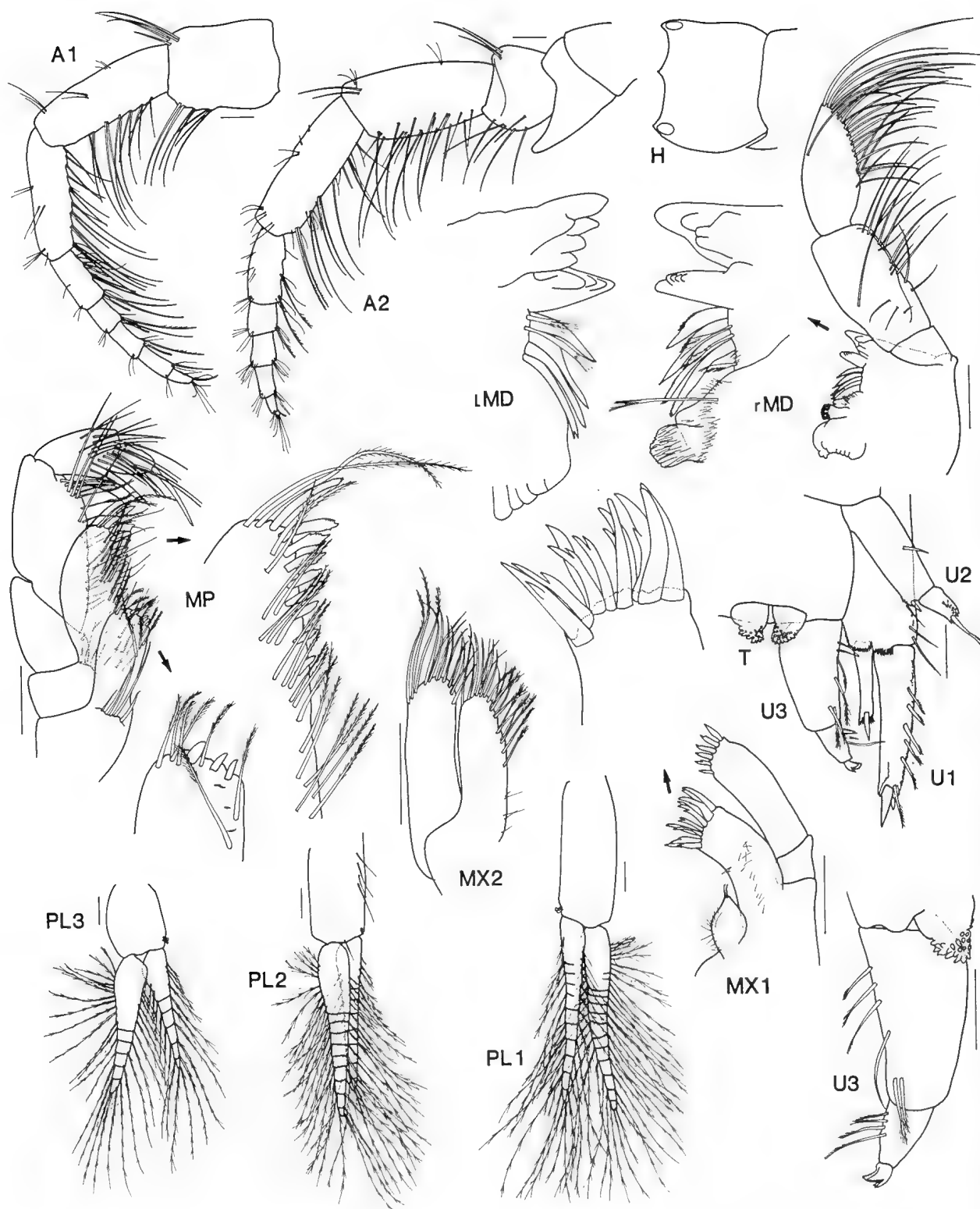


Fig. 20. *Paracerapus polutovi* Gurjanova, 1951, lateral view, male paratype, 6.2 mm, AM P41691; East Kamchatka, Bering Sea. Scales represent 0.1 mm.

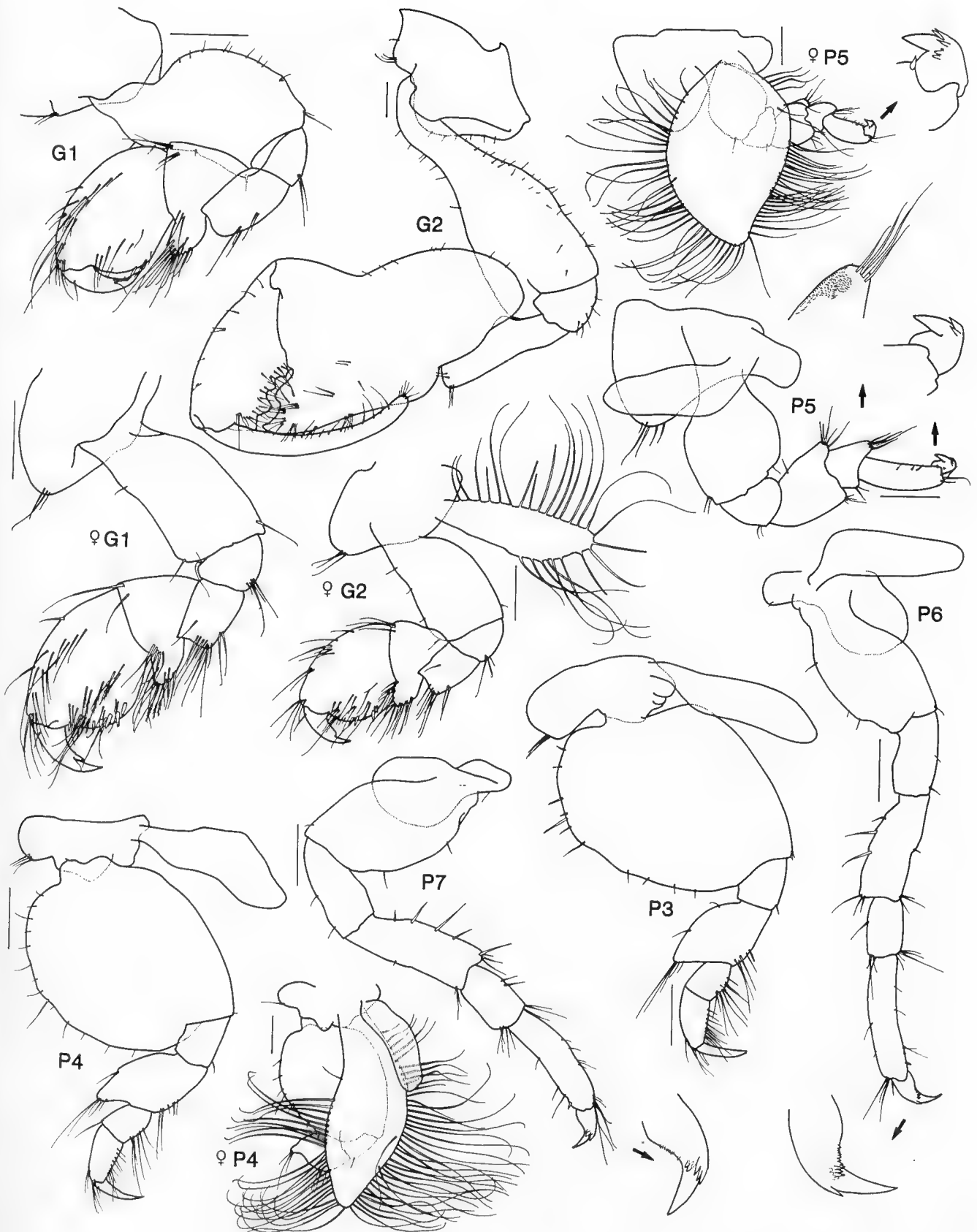


Fig. 21. *Paracerapus polutovi* Gurjanova, 1951, lateral view, male paratype, 6.2 mm, AM P41691; female, 6.1 mm, male, AM P41692; East Kamchatka, Bering Sea. Scales represent 0.2 mm.

corner rounded, subocular margin deeply recessed, anteroventral corner subquadrate, ventral margin horizontal, posterior margin vertical. *Antenna 1*: short,  $0.27 \times$  body length, without scales; peduncular article 1 with very weak keel, length  $0.7 \times$  peduncular article 3; accessory flagellum absent; flagellum long, 5-articulate (female 5), aesthetascs absent, article 1 long,  $2 \times$  article 2. *Antenna 2*: subequal in length to antenna 1; peduncle without scales; flagellum 5-articulate (female 6), article 1 long,  $2.2 \times$  article 2. *Epistome* and *upper lip*: fused. *Mandible*: left incisor with 4 cusps, right incisor with 4 cusps; left and right lacinia mobilis each with 4 cusps; left accessory setal row with 4 pappose robust setae, with 2 intermediate plumose setae, right accessory setal row with 4 pappose robust setae, with 3 intermediate plumose setae; molar triturating, molar flake on left and right side, molar seta only on right side; palp article 2 short, broad, length  $1.8 \times$  breadth,  $1 \times$  article 3 with 1 proximal A2-seta, with 5 posterior submarginal A2-setae, with 3 proximal and 10 posterior submarginal B2-setae, without D2-setae; article 3 clavate, long,  $2.2 \times$  breadth, with 1 proximal A3-seta, with distal A3-setae, with 10 posterior submarginal B3-setae, with 13 D3-setae and 3 E3-setae. *Maxilla 1*: inner plate small, with 2 simple apical setae; outer plate with 10 setal-teeth; palp with 6 terminal robust setae, without subterminal setae, flag seta present on distolateral corner. *Maxilla 2*: outer plate broader than inner; inner plate with setae distally along medial margin. *Maxilliped*: inner plate subrectangular with 3 nodular robust setae, without subterminal robust setae on medial corner, oblique setal row with 8 plumose setae; outer plate with 2 apical plumose setae, and 8 apicomedial robust setae; palp article 2, length  $2 \times$  breadth, article 3, length  $1.7 \times$  breadth.

*Peraeonite 1*: without lateral keel in male. *Peraeonite 2*: without sternal keel in male. *Peraeonite 5*: male, length  $1.7 \times$  breadth, female, length  $0.8 \times$  breadth. *Gnathopod 1*: subchelate; coxa not fused to peraeonite 1 in male or female, length  $1.2 \times$  depth, without anteroventral lobe; basis in male with sparse setae along anterior margin, in female with sparse setae along anterior margin, without robust setae along anterior margin; carpus length  $0.76 \times$  depth with setose posterior lobe, anterior margin without setae in male and female; propodus length  $1.6 \times$  depth, with 7 rows of anteromedial setae; palm acute, without setae, with barbed robust setae. *Gnathopod 2*: carpocheate in male, subchelate in female; coxa not fused to peraeonite 2 in male or female, length  $1.7 \times$  depth, without sharp anteroventral cusp; basis long, bottle-shaped, length  $2.6 \times$  breadth; carpus massive, very long, slender, length  $1.5 \times$  breadth, posterior margin without tooth; palm obtuse, broadly excavate, without anterodistal tooth, posterodistal tooth well defined, medium in size, length  $1 \times$  width, without robust setae; propodus broad, curved, length  $2.4 \times$  width, without tooth on posterior margin, with teeth along posterior margin; dactylus, length  $10.4 \times$  propodus.

*Peraeopod 3*: coxa not fused to peraeonite 3 in male or female, length  $2.3 \times$  depth, without anteroventral

lobe; basis length  $1.1 \times$  breadth, without inflated anterodorsal corner, with setae along anterior margin, without denticles along anterior margin; ischium length  $1.2 \times$  breadth; merus without ridges; carpus with 4 simple setae along distal half of anterior margin, with 10 simple setae along posterior margin; propodus with a few setae along posterior margin. *Peraeopod 4*: coxa not fused to peraeonite 4 in male or female, length  $2.4 \times$  depth, without anteroventral lobe; basis length  $1.2 \times$  breadth, without setal group along anterior margin; ischium long, length  $1.4 \times$  breadth; carpus without setae along distal half of anterior margin, with 7 simple setae along posterior margin; propodus with 8 simple setae along posterior margin. *Peraeopod 5*: coxa, length  $1.5 \times$  depth, without patches of small setae; anterior lobe of merus not extending beyond anterior margin of carpus, posterior lobe with 4 simple setae; propodus with 4 setae along posterior margin, dactylus short, uncinatate with two accessory spines. *Peraeopod 6*: coxa without setal fringe ventrally, without patch of small setae; basis without anterior setae, without small denticles along posterodistal margin; merus, length  $2.5 \times$  breadth, without small anterodistal lobe; carpus without anterodistal lobe, without posterodistal lobe, posterodistal corner bearing small setal bunch; propodus, anterodistal corner bearing large setal bunch; dactylus short, uncinatate with rows of accessory spines. *Peraeopod 7*: coxa with posterodorsal lobe, without patch of small setae; basis without denticles along anteroproximal margin, without small denticles along posterodistal margin; merus, length  $3 \times$  breadth, without small anterodistal lobe, posterodistal corner bearing small setal bunch; carpus without anterodistal lobe, without posterodistal lobe, anterodistal corner bearing large setal bunch; propodus posterodistal corner bearing small setal bunch, anterodistal corner bearing small robust seta; dactylus short, uncinatate with rows of accessory spines.

*Oostegites*: from gnathopod 2 to peraeopod 5. *Gills*: from peraeopod 3 to peraeopod 6.

*Pleopods 1 to 3*: decreasing in size. *Pleopod 1*: peduncle without patch of small setae, with 2 small distomedial hooks; rami subequal in length; inner ramus without patch of small setae, 11-articulate; outer ramus, article 1 with straight medial margin, 15-articulate. *Pleopod 2*: peduncle without patch of small setae, with 2 small distomedial hooks; biramous, inner ramus without patch of small setae, rami subequal in length, inner ramus 8-articulate; outer ramus broad, 10-articulate, without patch of small setae. *Pleopod 3*: peduncle without patch of small setae, with 2 small distomedial hooks; rami subequal in length, without patch of small setae. *Uropod 1*: biramous, peduncle with distoventral corona of cuticular teeth, length  $1.3 \times$  outer ramus, without distoventral spine; outer ramus with lateral row of denticles, with 6 lateral setae, with large apical robust seta; inner ramus length  $0.53 \times$  outer ramus, without setae, with apical robust seta. *Uropod 2*: uniramous, peduncle



length  $2.5 \times$  breadth,  $2.8 \times$  ramus; ramus small, with denticles and large apical robust seta. *Uropod* 3: uniramous peduncle length  $1.6 \times$  breadth; ramus with 3 curved spines. *Telson*: length  $0.5 \times$  breadth, cleft to base, each lobe with 22 to 25 anteriorly directed spines in two rows.

**Tube.** Unknown.

**Remarks.** According to Kudrjashov (1975) *Paracerapus polutovi* and *P. comparativus* (Kudrjashov, 1975) are closely related. Kudrjashov (1975) believed that the shape of the propodus of gnathopod 1 clearly distinguished the two species, but our illustration of the propodus is different to that of Gurjanova (1951), and appears more similar to that of Kudrjashov for *P. comparativus*. In males the carpochele palm of *P. polutovi* is not as recessed as that of *P. comparativus*, but this condition may be related to the age of the individuals. It is possible that these two species are synonymous. *Paracerapus comparativus* is known from Iturup in the Kuril Islands, an island chain extending south from the Kamchatka Peninsula. *Paracerapus polutovi* occurs in the Commander Islands to the east of the Kamchatka Peninsula. *Paracerapus comparativus* needs to be redescribed in detail before its true relationship to *P. polutovi* can be considered.

**Distribution.** East Kamchatka and Commander Island, Bering Sea, littoral to 29 m depth.

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Table 1. Matrix for HENNIG86 analysis of *Ericthonius* group generic relationships.

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	14	17	18	19	20	21
<i>Gammaropsis</i>	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<i>Pseudischyrocerus</i>	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0	0	0	1	0	1
<i>Pseuderichthonius</i>	0	0	2	0	1	2	1	0	0	0	0	?	0	0	0	0	0	1	1	0	1
<i>Ericthonius</i>	0	0	2	0	1	1	0	0	0	0	0	0	0	0	0	1	0	1	1	0	1
<i>Bathypoma</i>	0	1	2	0	0	0	1	0	1	1	1	0	1	1	1	1	1	1	1	1	2
<i>Cerapus</i>	0	0	2	0	1	2	1	0	1	1	1	0	1	1	1	1	1	1	1	1	2
<i>Notopoma</i>	0	1	2	0	1	1	1	0	1	1	1	0	1	1	1	1	1	1	1	1	2
<i>Paracerapus</i>	0	0	2	0	1	2	1	0	1	0	0	0	1	1	1	1	1	1	1	1	2
<i>Runanga</i>	0	0	1	0	1	1	1	0	1	1	1	0	0	1	1	1	1	1	1	0	2
<i>Siphonoecetes</i>	1	0	2	1	2	0	1	0	1	1	0	0	0	2	0	1	0	1	0	0	0
<i>Caribboecetes</i>	1	0	2	1	2	0	0	1	1	1	1	0	2	2	0	1	2	2	0	0	1
<i>Concholestes</i>	1	0	2	1	0	0	0	1	1	1	1	0	2	2	0	0	2	1	0	0	1
<i>Africoecetes</i>	1	0	2	1	2	0	2	1	1	1	0	0	1	2	1	0	1	1	0	0	1
<i>Rhinoecetes</i>	1	0	2	1	0	0	0	0	1	1	1	0	2	2	1	1	1	1	0	0	1
<i>Borneoecetes</i>	1	0	2	1	0	0	2	0	1	1	1	0	1	2	1	1	1	1	0	0	1
<i>Bubocorophium</i>	1	0	2	2	0	0	2	1	1	1	1	0	2	2	1	1	0	1	0	0	1
<i>Australoecetes</i>	1	0	2	1	2	0	1	0	1	1	1	0	2	2	1	0	2	2	0	0	0
<i>Polynesoecetes</i>	1	0	2	1	2	0	2	0	1	1	1	0	2	2	1	0	2	2	0	0	0
<i>Corocubanus</i>	1	0	2	2	2	0	2	0	2	2	2	0	?	2	?	0	2	2	0	0	1



**Description of the Unique**  
***Parotia lawesii* × *Paradisaea rudolphi***  
**Hybrid Bird of Paradise**  
**(Aves: Passeriformes: Paradisaeidae)**

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**ABSTRACT.** A unique female-plumaged Australian Museum specimen (AM O. 40100) of a hybrid between Lawes' Parotia *Parotia lawesii* and the Blue Bird of Paradise *Paradisaea rudolphi* is described, illustrated and compared with female-plumaged specimens of the putative parents. The hybrid, from the Baiyer Valley, Papua New Guinea, exhibits an external morphology intermediate between the two parent species. The informal common name—Schodde's Bird of Paradise—is applied to this new bird of paradise hybrid combination.

FRITH, CLIFFORD B. & DAWN W. FRITH, 1996. Description of the unique *Parotia lawesii* × *Paradisaea rudolphi* hybrid Bird of Paradise (Aves: Passeriformes: Paradisaeidae). Records of the Australian Museum 48(2): 111–116.

During his work on the systematics of birds of paradise (Paradisaeidae), Dr Richard Schodde discovered a skin in the Australian Museum, Sydney, that appeared to be the product of a previously unknown intergeneric hybrid mating between Lawes' Parotia *Parotia lawesii* and the Blue Bird of Paradise *Paradisaea rudolphi* (Christidis & Schodde, 1993). Schodde suggested we examine the specimen. We did so, and found ourselves in complete agreement with his interpretation of its appearance.

While 13 intergeneric and seven intragenetic hybrid birds of paradise have been reported to have occurred in the wild, based on relatively few specimens (Stresemann, 1930; Mayr, 1941, 1962; Gilliard, 1969; Fuller, 1979), the bird Schodde brought to light is the first hybrid known involving the combination of *Paradisaea* and *Parotia*. The specimen has been

described only as being in feminine plumage with "the ventral markings and dusky bill of *Parotia lawesii* and the all black head, white orbital marks and heavy decurving bill of *Paradisaea rudolphi*" (Christidis & Schodde, 1993). For detailed descriptions and illustrations of the plumages of these parental species, see Gilliard (1969), Cooper & Forshaw (1977), Beehler *et al.* (1986) and Coates (1990).

The purpose of this note is to provide a full description and an illustration of this unique and significant specimen in the zoological literature. This is highly desirable because of the considerable historical and contemporary interest in the group generally (Gilliard, 1969; Schodde, 1976; Diamond, 1981, 1986; Beehler, 1989; Christidis & Schodde, 1992) and hybrids within it in particular (Stresemann, 1930; Iredale, 1950; Mayr,

1962; Fuller, 1979; Christidis & Schodde, 1993). The loss to science from a major national museum of an intergeneric wild hybrid specimen (*Epimachus fastuosus* × *Astrapia nigra*, previously referred to as *Epimachus ellioti*), one of only two, emphasises the vulnerability of such uniquely valuable specimens (Fuller, 1979).

The following description is of Australian Museum female specimen O. 40100. It was collected by the New Zealand anthropologist Professor Ralph Bulmer on 15 February 1956 at Trepikama, Baiyer Valley, New Guinea at c. 1616 m asl. In view of this location, the specimen must represent a *Parotia lawesii lawesii* × *Paradisaea rudolphi margaritae* hybrid (Gilliard, 1969; Diamond, 1972; Schodde & McKean, 1973; Cracraft, 1992). The subspecies *P. l. exhibita*, described from the Mount Hagen area by Iredale (1948) is now considered invalid and a synonym of the nominate subspecies [hence *Parotia l. (exhibita) lawesii* of Table 1]. Directly comparable material of these two putative parent taxa is limited in Australian collections to a single female *Parotia l. lawesii* from Haiyeria, New Guinea, collected by Captain Ned B. Blood on 1 October 1946 (AM O. 38564) and a female-plumaged, but immature and dark-billed male *Paradisaea r. margaritae* from Upeta, Baiyer River Valley, New Guinea, collected by Ralph Bulmer on 25 October 1955 at c. 1830 m asl (AM O. 40078). In addition, another five adult female specimens of *Paradisaea r. margaritae* and four female *Parotia l. lawesii* exist in overseas collections (see Table 1). As the hybrid is morphologically intermediate between the typical female plumages of the putative parents, the limited material available is adequate and additional material would add little for the present purposes. To save space below, we use only *Parotia* and *Paradisaea* to indicate the two putative parent species, unless otherwise indicated. We refer, in parentheses, to numbers allocated to colours in Smithe (1975) to indicate only the colour closest to that being described.

This hybrid bird has the general appearance of a female-plumaged *Parotia lawesii* (Plate 1) and would in all probability be identified as a Lawes' Parotia if seen alive in the wild, unless exceptionally prolonged good views of it be obtained by an expert observer. It is therefore convenient and appropriate to describe it with respect to how it differs from the female-plumaged *Parotia* parent.

The most obvious influences of *Paradisaea* genes are expressed by (a) the semicircle of fine silver-white feathers above and below the eyes, narrower in the hybrid than in *Paradisaea* and with many of the feathers, particularly toward the front of the upper semicircle, finely tipped with rufous; (b) the bill, which is clearly that of *Paradisaea* in size and shape but which has the narrow slit nostril of *Parotia*, as opposed to the broader and rounder one of *Paradisaea* (Fig. 1); (c) the lack of any sign of a supra-nasal tuft of feathers (of Schodde & McKean, 1973); and (d) the almost total masking of pale, black-tipped, feathers that form an obvious broad malar stripe and conspicuously pale throat in normal female *Parotia* (see Plate 1).

The hybrid, while lacking the malar stripe, does not have the "all black head" of *Paradisaea*, as was indicated (Christidis & Schodde, 1993), but is dark rich chestnut-headed (223) and is blackish only on the lores and forecrown, as in *Parotia*. The chin, throat and upper chest are rich chestnut (223A) barred with black, and therefore much darker than in the pale-throated (223D) *Parotia*. Christidis & Schodde (1993) noted that the hybrid had the "dusky bill of *Parotia lawesii*" but as the bill colour of this specimen is the same as that of the immature male *Paradisaea* (AM O. 40078) used here for comparison (Plate 1), and that of a fledgling examined by D. Haddon (*in litt.* to CBF) was also dark, this may merely indicate immaturity and not the influence of *Parotia*.

The throat and upper breast of the hybrid are a much darker, richer chestnut than that of *Parotia*, and this darker area extends downward to where the blackish-brown throat and chest colour extends in *Paradisaea*, thus expressing the influence of the latter parent (see Plate 1). The nape, back and rump of the hybrid (223A) are similar to, but slightly less rich and red than, those of female *Parotia*.

The mid and rear crown feathers of the hybrid are consistently short, compact and rounded throughout, unlike those of *Parotia* spp., in which these feathers become longer and broader from mid-crown to the rear and include conspicuously elongated narrow feathers behind each eye that form obvious "ear tufts" (Fig. 1).

The upper wing and tail of the hybrid are unlike the rich dark chestnut brown (223) of *Parotia* in being clearly less chestnut, paler (121) and with a slight bronze sheen, which in certain lights has a pale silvery-blue hue, expressing the genetic influence of *Paradisaea*. The under surface of the tail of the hybrid is likewise, but more so, paler (28) and less rufous than in *Parotia* (21) with a pale silver-greyish sheen. The central shafts of the underside of the tail feathers are not dark as in *Parotia* but are pale, almost whitish, as in *Paradisaea*. The bases of the central tail feathers, particularly the central pair, are whitish, unlike *Parotia* but as in *Paradisaea*. The hybrid's underwing is slightly paler, less brown, than that of *Parotia*, but less markedly so than the tail. The trailing edges of the basal half of the undersurface of the hybrid's primaries are broadly and conspicuously buff-brown (223C). These are also paler (whitish) in *Paradisaea*, whereas the primaries of *Parotia* are uniform in colour throughout. The tail feathers of the hybrid are intermediate between the broader ones of *Parotia* and the narrower, more pointed ones of *Paradisaea*; however, differences in age may complicate this character, which limited material does not permit us to examine.

The external characters of the hybrid bird are shown together with those of a female-plumaged *Parotia l. lawesii* and *Paradisaea r. margaritae* from the same area in Plate 1.

The short tenth, or outer, primary of *Parotia lawesii* is highly modified, far more so in adult males than in females. Figure 1 shows that the shape of this primary in the hybrid is somewhat intermediate in degree of

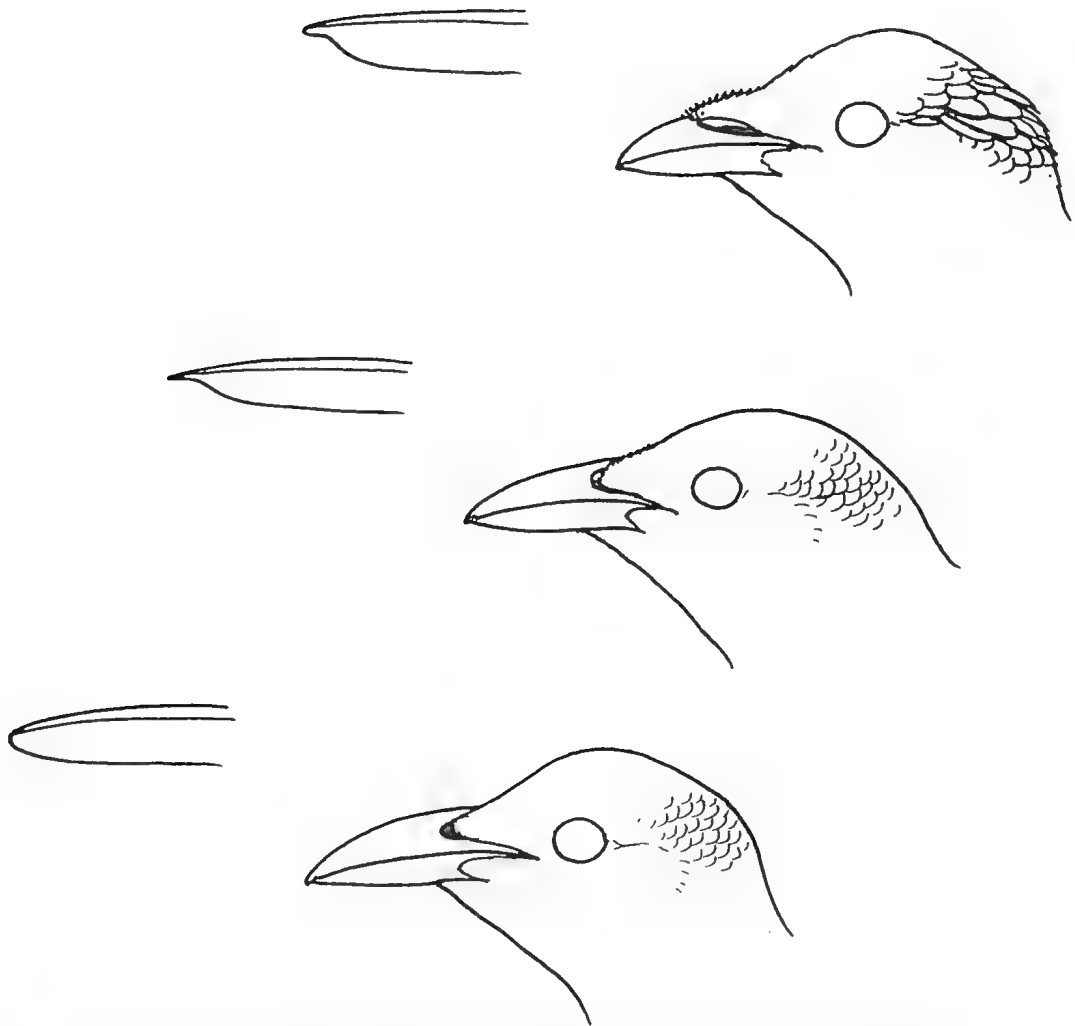


Fig. 1. Heads and distal end of the tenth, or outer, primary of *Parotia lawesii* (top), *Paradisaea rudolphi* (bottom) and the hybrid between these two (centre) showing differences in feather tip, bill and nostril shape and head feathering.

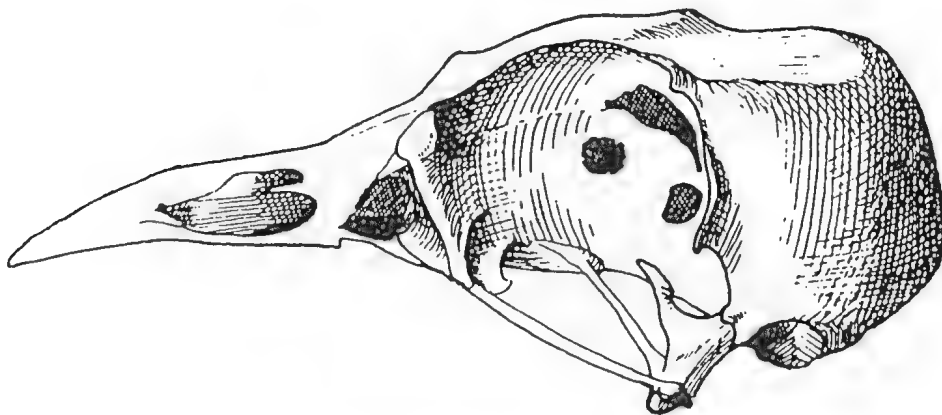


Fig. 2. Skull of Lawes' Parotia *Parotia lawesii* showing the concavity of the crown dome, to accommodate large muscles that manipulate plumes arising from behind the ears of adult males. From Stonor (1938).





**Plate 1.** The appearance of the unique Australian Museum specimen AM O. 40100 female-plumaged *Parotia lawesii* × *Paradisaea rudolphi* hybrid, or Schodde's Bird of Paradise, (centre) and that of the putative parent taxa AM O. 38564 female *Parotia lawesii* (*exhibita*) *lawesii* (top) and AM O. 40078 immature male *Paradisaea rudolphi margaritae* (bottom). Painting by William T. Cooper.

modification between that of female *Parotia* and the female-plumaged *Paradisaea*, but it should be noted the ages of these birds are unknown. Since the female *Parotia* is in active wing moult, we cannot, however, comment on the relative length of this feather (much longer in *Paradisaea* than in *Parotia*).

A novel but not readily apparent character of both sexes of *Parotia* spp., is that the crown or dome of the skull is conspicuously concave, or "dished" (Fig. 2), a remarkable adaptation to accommodate large muscles required for the manipulation of the plumes of displaying adult males (Frith & Frith, 1981). Notwithstanding the general *Parotia*-like appearance of the hybrid, however, it has only the slightest concavity of the skull, its crown profile being more like that of *Paradisaea*, in harmony with its *Paradisaea*-like bill.

Table 1 presents measurements of the hybrid bird and those of *Parotia* and *Paradisaea* in Australian collections. The hybrid's wing length is similar to that of *Parotia*, its tail length is shorter than that of adult *Parotia* and immature *Paradisaea* but longer than adults, its bill width is near intermediate, while its tarsus and bill lengths are far closer to those of *Paradisaea*.

**Lawes' *Parotia lawesii* × Blue Bird of Paradise *Paradisaea rudolphi* hybrid—Schodde's Bird of Paradise**

While scientific and vernacular names for wild hybrid birds are not entirely desirable or justified and have no formal standing in zoological nomenclature, most hybrid birds of paradise have been given one or both (Iredale, 1950; Fuller, 1979). No scientific name should be established for the above hybrid. We do not suggest a formal common name but would, in keeping with tradition, like to see this hybrid at least informally known as Schodde's Bird of Paradise to appropriately acknowledge Dr Richard Schodde's discovery, as part of his far more significant systematic work on the Paradisaeidae, expressed in both his numerous publications and the fine and valuable collection of Paradisaeidae in the Australian National Wildlife Collection at the CSIRO in Canberra.

**ACKNOWLEDGMENTS.** For access to and assistance with the examination of specimens in their care we thank Walter Boles and Wayne Longmore and the Australian Museum, Sydney; Mary LeCroy and the American Museum of Natural History, New York; Dr Robert Pry-Jones, Peter Coulston, Michael Walters and the British Museum of Natural History, Tring; Dr H. Hoerschelmann and the Zoologisches Museum, Hamburg; Dr Allen Allison and Carla Kishinami and the Bernice Bishop Museum, Honolulu; Dr Frank Bonaccorso, Iliaiah Bigilale, Paul Wanga and the National Museum and Art Gallery of Papua New Guinea, Port Moresby, and Dr Fred C. Sibley and the Peabody Museum, New Haven. Dr Bruce Beehler, Walter Boles, Brian Coates, and Dr Richard Schodde kindly provided constructive comment on a draft of this contribution. We sincerely thank William T. Cooper for his interest and kindness in producing the fine and invaluable painting. We particularly thank Dr Richard Schodde for identifying the hybrid and for kindly directing us to it.

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**Table 1.** Measurements<sup>1</sup> of adult female specimens<sup>2</sup> of *Paradisaea rudolphi margaritae*, *Parotia lawesii (exhibita) lawesii* and an immature female hybrid between these taxa from Papua New Guinea.

Taxon Collection #	Wing length	Tail length	Tarsus length	Bill length	Bill width
<i>Paradisaea rudolphi margaritae</i>					
AMNH 348209	148	90	37.9	40.5	9.0
AMNH 705629	146	94	36.6	39.0	8.6
ZMH P15 66.35	146	88	36.6	38.4	9.2
ZMH P15 66.36	145	91	39.5	40.8	8.5
PMNH 7576	147	86	38.8	40.5	9.1
MEAN	146	90	37.9	39.8	8.9
<i>Paradisaea r. margaritae</i> <i>Parotia l. (exhibita) lawesii</i>					
HYBRID AM O. 40100	146	93	39.6	37.3	7.2
<i>Parotia lawesii (exhibita) lawesii</i>					
NHM 1939.12.9.1533	143	93	46.0	31.7	5.8
NHM 1939.12.9.1571	147	99	46.6	32.8	5.8
BBM 60084	143	97	45.4	33.2	5.5
AM O. 38564	147	95	45.9	29.0	6.5
PNGM 25866	144	94	46.4	31.6	5.4
MEAN	145	96	46.1	31.7	5.8

<sup>1</sup> Wing length is the straightened, flattened, maximum length; tail length from point of entry of central pair into skin to tip of longest feather; tarsus from depression in the angle of intertarsal joint to distal end of tarsometatarsus; bill length from tip to union with anterior margin of skull and bill width at anterior nostril. Measurements in millimetres.

<sup>2</sup> AMNH —American Museum of Natural History, New York; ZMH —Zoologische Museum, Hamburg; PMNH —Peabody Museum, New Haven; AM —Australian Museum, Sydney; NHM —The Natural History Museum, Tring; BBM —Bernice Bishop Museum, Honolulu; PNGM —Papua New Guinea Museum, Port Moresby.

## Descriptions of Two New Species of the Genus *Pempheris* (Pisces: Pempheridae) from Australia, with a Provisional Key to Australian Species

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**ABSTRACT.** *Pempheris ornata* n.sp. is described from 34 specimens collected at sites along the southern Australian coast, from Rottnest Island in Western Australia east to Rapid Bay, South Australia. The scales of this species are cycloid, deciduous, and large, the last characteristic resulting in uniquely low counts of 32-39 lateral-line scales. It is also immediately separable from other *Pempheris* by: 6-7 yellow-orange or golden-brown stripes on anterior body, reducing to three stripes on caudal peduncle (stripes dark brown in preserved specimens); body cream-coloured or transparent; dark linear light organ visible through body wall between pelvic- and anal-fin origins, with a slight bifurcation around anus; segmented anal-fin rays 27-30; 14-17 circumpeduncular scales. *Pempheris ypsilychnus* n.sp. is found from Shark Bay in Western Australia, along the north coast to Cape York, and south to Moreton Bay in Queensland. It is described on the basis of 63 specimens and is distinguished from congeners by the following combination of characters: scales ctenoid and adherent; pelvic axillary scale present; dark Y-shaped light organ visible through body wall between pelvic- and anal-fin origins, with wide bifurcation around anus; gill-raker counts on first arch 6-8 + 19-22 = 25-30 (usually 26-27); lateral-line scales 62-74 (usually 63-69). Although the exact membership of the genus is questionable at this time, a provisional key to the Australian species of *Pempheris* is provided.

MOOI, RANDALL D., & RODNEY N. JUBB, 1996. Descriptions of two new species of the genus *Pempheris* (Pisces: Pempheridae) from Australia, with a provisional key to Australian species. Records of the Australian Museum 48(2): 117-130.

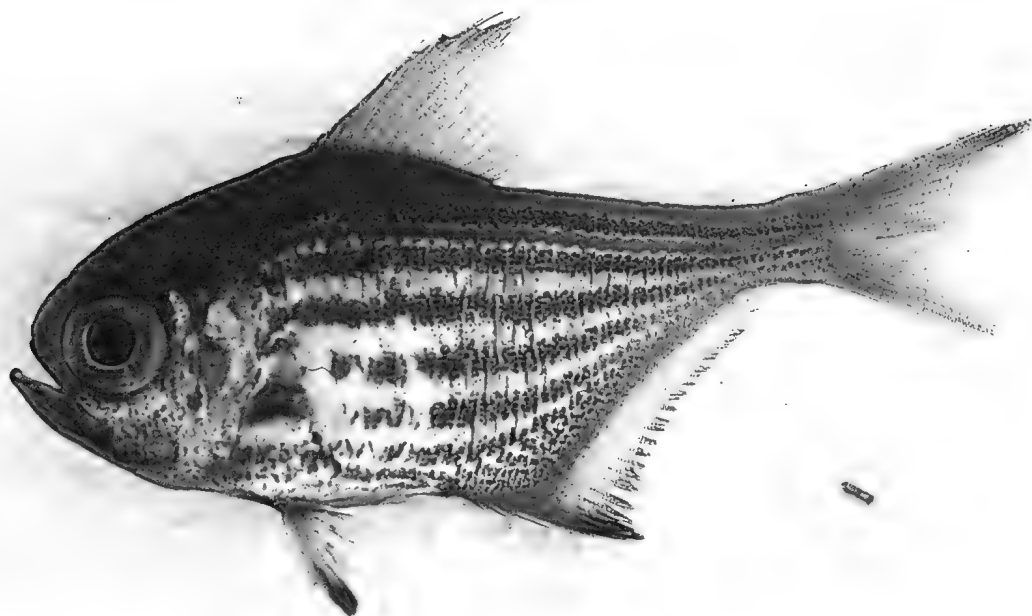


Fig. 1. Holotype of *Pempheris ornata* n.sp., AMS I.33831-001, 71.4 mm SL, Rapid Bay, South Australia, freshly caught. Photo by R.H. Kuiter.



Fig. 2. *Pempheris ornata* at the type locality of Rapid Bay, South Australia. Photo by R.H. Kuiter.



Fig. 3. A school of *Pempheris ornata* at the type locality of Rapid Bay, South Australia. Photo by R.H. Kuiter.

### Introduction

Fishes of the family Pempheridae, commonly known as bullseyes or sweepers, are found on rocky and coral reefs of the tropical and temperate Indo-Pacific and western Atlantic Oceans to depths of 100 m. Since Tominaga (1965), the family has been restricted to include two genera of small to medium-sized fishes (usually < 200 mm SL) characterised by strongly compressed bodies, a single short dorsal fin, large eyes, and the lateral line extending well onto the caudal fin: *Pempheris* Cuvier, 1829 with over 30 nominal species (of which fewer than 20 are valid), and *Parapriacanthus* Steindachner, 1870 with 8 nominal species (of which about four are valid). Although there is clear support that the members of the two genera collectively form a monophyletic group (Tominaga, 1968), the monophyly of each individual genus has yet to be rigorously tested. Preliminary study of osteology, myology and internal organ morphology by the senior author suggests that neither genus, as currently conceived, is monophyletic.

Evidence was presented by Tominaga (1986) that the Glaucosomatidae, a family of medium-sized to large fishes in one genus (*Glaucosoma*), is closely related to the Pempheridae. This was supported by Johnson (1993: 19), who proposed that the two families should be included as subfamilies under the Pempheridae. However, this taxonomic change is unnecessary if the two groups are each monophyletic—they can be considered sister families.

Australia boasts the highest diversity of these related taxa, and a number of the species are endemic to its coastlines. Records are known for all four species of *Glaucosoma* (of which *G. hebraicum*, *G. magnificum*, *G. scapulare* are endemic), three of the probable four species of *Parapriacanthus* (*P. elongatus* endemic), and almost half of the valid members of *Pempheris* (of which *P. affinis*, *P. compressa*, *P. klunzingeri*, *P. multiradiata* are endemic; New Zealand reports of *P. compressa* appear to be erroneous [e.g., Griffin, 1928; Paulin *et al.*, 1989]). While examining material for a systematic revision of the family Pempheridae, the senior author

"rediscovered" what appeared to be two new Australian endemic species of *Pempheris* that had been originally described in an unpublished thesis by the junior author some 15 years earlier (Jubb, 1977). This paper describes the two new species, which are here assigned to the genus *Pempheris* pending a systematic revision of the Pempheridae. These two new species raise the number of Australian endemic *Pempheris* to six. A provisional key to the Australian *Pempheris* is provided.

### Methods and Materials

Specimen sizes are reported as standard length (SL) in mm, measured from the tip of the snout to the middle of the posterior edge of the hypural plates. All morphometric measurements are presented as percentages of SL, with holotype values presented first, followed, in parentheses, by mean and range values of remaining specimens. Head depth was measured at the vertical of the posterior margin of the eye. Predorsal, prepelvic and preanal lengths were measured from the tip of the snout to the origin of the relevant fin. Body depth was measured at the vertical from the dorsal origin to the ventral belly. Peduncle depth was the horizontal distance measured from the anal-fin insertion (base of last segmented ray). All other measurements follow Hubbs & Lagler (1949) or are self-explanatory.

Counts are presented with the holotype value(s) first, followed, in parentheses, by the mode, range, and frequency comments for the remaining specimens. Calculation of mode and determination of range for number of lateral-line scales and gill rakers includes counts of both sides. Gill-raker counts are provided as upper + lower limb counts of outer elements (including rudiments) of the first arch. Caudal-fin ray counts are separated into number of principal caudal rays (branched rays + 1 unbranched ray above and below) and procurent rays (remaining unbranched elements anterior to the principal rays). Procurent ray number is provided as upper and lower counts, with unsegmented and then segmented elements separated by a comma. Predorsal scale counts were made to the vertical from the anterior margin of the pupil. All other counts follow Hubbs & Lagler (1949). Cheek scale row number was often difficult to determine, either because scales are missing (*Pempheris ornata*) or because scales are crowded and do not form obvious rows (*P. ypsilychnus*).

Counts and measurements are based on all specimens listed as material examined, except in cases where damage (particularly for fin-ray measurements) precluded their use. Statistical comparisons were performed using SAS Ver. 6 (SAS Institute Inc., SAS Campus Dr., Cary, NC, USA, 27513).

Material is deposited in the following institutions: AMS—Australian Museum, Sydney; BMNH—The Natural History Museum, London; CSIRO—CSIRO Marine Laboratories, Hobart; MPM—Milwaukee Public Museum, Milwaukee; NMV—Museum of Victoria, Melbourne; NTM—Northern Territory Museum, Darwin;

ROM—Royal Ontario Museum, Toronto; SMNS—Staatliches Museum für Naturkunde in Stuttgart, Stuttgart; WAM—Western Australian Museum, Perth; USNM—National Museum of Natural History, Washington, D.C.

### *Pempheris ornata* n.sp.

Figs 1–4a, 5–6; Table 1

*Pempheris* sp.—Hutchins & Thompson, 1983: 40, fig. 183 (brief description, colour illustration).—Allen, 1985: fig. 229 (colour photograph).—Hutchins & Swainston, 1986: 66, fig. 336 (brief description, colour illustration).—Gomon, 1994: 608, fig. 536 (description, colour photograph).—Hutchins, 1994: 49, as *P. sp.* 3 (Western Australian distribution).

**Material examined.** HOLOTYPE, AMS I.33831-001, 71.4 mm, South Australia, Rapid Bay (35°31'09"S 138°11'05"E), 9.1 m, R.H. Kuiter, 21 March 1995.

PARATYPES, 19 specimens, 52.7–75.5 mm, all collected with the holotype. AMS I.33831-002, 63.2 mm; BMNH 1995.7.17: 1, 54.8 mm; MPM 31496, 2: 66.6–67.9 mm; NMV A15835, 4: 53.2–75.5 mm; NTM S.14104-001, 53.6 mm; ROM 69303, 68.2 mm; USNM 337545, 2: 51.1–75.1; WAM P30996-001, 2: 52.7–66.0.

**Other material:** 20 specimens, 31.3–67.7 mm. AMS I.20221-002, 58.5 mm, Western Australia, Recherche Arch., Mondrain Island (34°08'S 122°14'E), 30 m, B.C. Russell, 21 March 1978; AMS I.20186-001, 2: 51.4–52.3 mm, South Australia, Kangaroo Island, Penneshaw (35°44'S 137°58'E), 9 m, B. Russell and R. Kuiter, 12 March 1978; AMS I.20247-013, 3: 31.1–35.0 mm, Western Australia, Rottnest Island, Kingston Reefs (31°59'S 115°33'E), 8 m, B. C. Russell, 12 April 1978; WAM P.27916-001, 2: 56.6–58.4 mm, Western Australia, Recherche Arch., Mondrain Island (34°08'S 122°14'E), 30 m, B. Russell, 21 March 1978; WAM P.28300-014, 11: 50.7–67.7 mm, Western Australia, east side of Lucky Bay (34°08'S 122°15'E), 11–12 m, J.B. Hutchins *et al.*, 16 April 1984.

**Diagnosis.** *Pempheris ornata* is unique among the Pempheridae in having: 6–7 yellow-orange or golden-brown stripes on anterior part of body, reducing to three stripes on caudal peduncle (stripes become dark brown in preserved specimens), body cream-coloured or transparent; 32–39 lateral-line scales. Other features which, in combination, help to distinguish it from other members of the family are: all scales cycloid and deciduous; circumpeduncular scales 14–17; segmented anal-fin rays 27–30; dark, linear light organ visible through body wall between pelvic- and anal-fin origins with a slight bifurcation around the anus; anterior light organ an upwardly-curving mass of finger-like projections communicating posteriorly with pyloric caeca.

**Description.** Dorsal-fin rays V,11 (V,11; IV–V,10–12, only once IV, rarely 10 or 12); anal-fin rays III,28



(III,28; III,27–30); pectoral-fin rays 16 (16; 15–17, extremes uncommon); pelvic-fin rays I,5; principal caudal-fin rays 9+8; upper procurrent rays 6,1 (6,1; 5–8,1–2); lower procurrent rays 4,1 (4,1; 3–5,1–2); lateral-line scales 35 left, 36 right (35; 32–39, rarely the extremes); scale rows above lateral line 4; scale rows below lateral line 7 (7; 6–8); cheek scale rows 4–6 (based on only 6 specimens); predorsal scales 28 (28; 25–33); circumpeduncular scales 15 (15; 14–17, rarely the extremes); gill rakers 7+22 (7+21; 7–8 + 21–24, rarely 24); total gill rakers 29 (28–30 almost equally common; 28–32, once 32).

As percentage of SL: head length 32.2 (32.0; 30.6–33.7); head depth 32.7 (33.1; 29.8–36.8); snout length 7.3 (7.0; 6.0–8.0); eye diameter 14.2 (14.5; 13.6–15.7); interorbital width 8.7 (8.2; 6.8–9.3); upper jaw length 18.9 (18.6; 17.2–20.0); predorsal length 42.0 (38.8; 34.6–42.9); prepelvic length 37.4 (39.9; 34.5–45.7); preanal length 57.0 (58.4; 54.9–64.3); pelvic-fin origin to anal-fin origin 22.8 (21.7; 19.6–25.3); body depth 44.4 (40.9; 34.4–46.3); pectoral-fin length 30.1 (29.8; 27.2–32.5); pelvic-fin length 21.0 (21.0; 19.6–22.4); dorsal-fin base 24.6 (22.8; 20.6–25.1); longest dorsal-fin ray 26.7 (25.2; 22.9–28.8); anal-fin base 43.7 (42.1; 38.8–45.6); longest anal-fin ray 18.9 (19.4; 14.9–22.2); caudal-peduncle length 13.0 (12.8; 9.6–14.8); caudal-peduncle depth 9.0 (10.0; 8.9–11.5); dorsal-fin origin to pelvic-fin origin 44.3 (41.0; 36.0–46.2); dorsal-fin origin to anal-fin origin 46.9 (44.2; 37.3–50.2); dorsal-fin origin to anal-fin insertion 58.1 (56.5; 53.3–59.1).

Caudal fin forked. All scales cycloid and deciduous, with flank scales large. Gular scaled. Pelvic axillary scale absent. Prepelvic area (breast) unkeeled, flat and broad.

Anterior light organ an upwardly curving mass of small finger-like projections communicating posteriorly with pyloric caeca (Fig. 4a). Posterior light organ linear with slight bifurcation around anus (not visible in view of Fig. 4a, 5).

**Coloration.** Holotype when freshly dead (Fig. 1): background colour on cheek, opercle, and body below lateral line iridescent silver; dorsal head, nape, and body above lateral line greyish to reddish; medial dark stripe along predorsal scales to dorsal-fin origin; dark stripe at level of dorsal part of eye extending to opercular opening, then merging with the upper-most body stripe; margins of jaws dark; lower part of cheek dark; iris yellowish; body below dorsal fin with 7 golden-brown stripes, with middle stripes brightest by having fewest darker chromatophores; number of body stripes decreasing posteriorly to three on caudal peduncle, ending at base of caudal-fin rays; stripes become increasingly reddish posteriorly; all fins with pinkish to reddish cast; dorsal fin pinkish hyaline, with dark anterior edge and dark distal tips on last two spines and first three segmented rays; anal fin quite red basally and on first few segmented rays, remainder pinkish hyaline with black tips on all but last 5 segmented rays, black covering 1/3 length of first 3 rays and about 1/4 length of

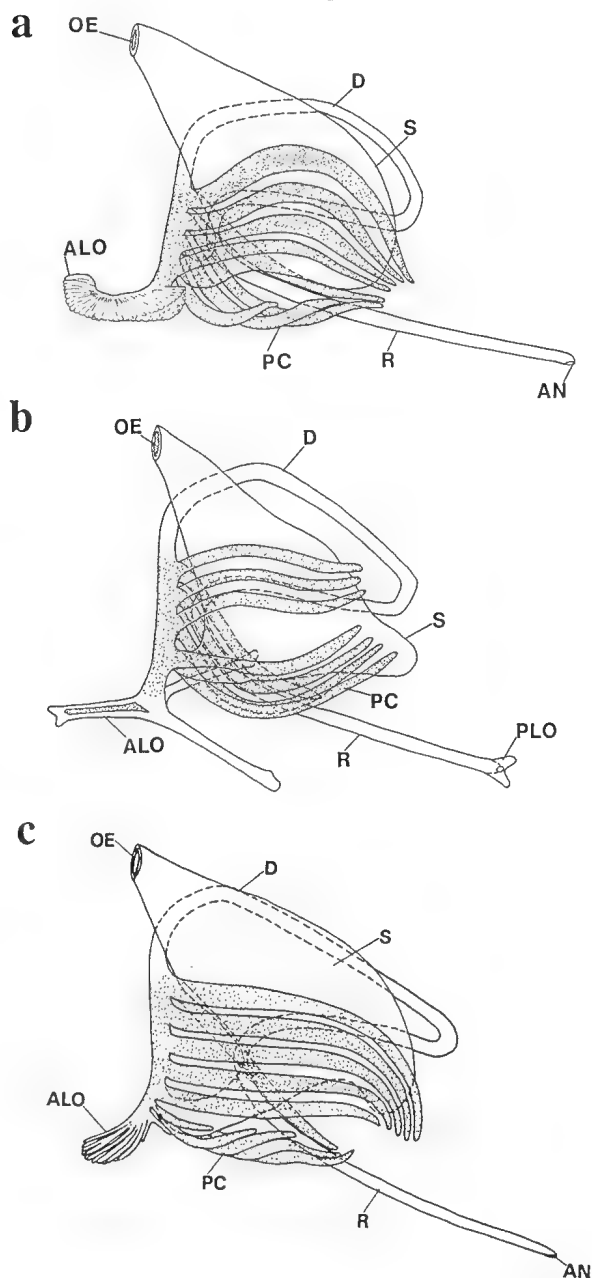
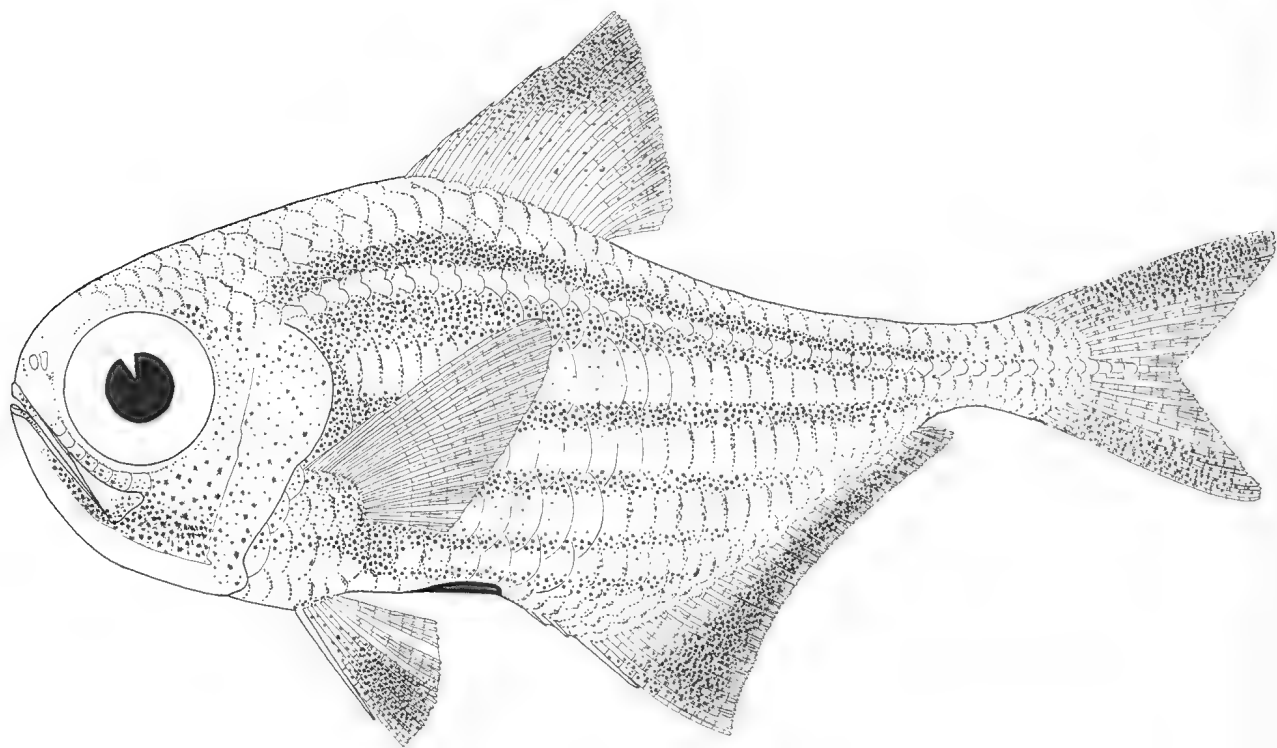


Fig. 4. Light organs of three species of *Pempheris*, left lateral aspect. (a) *P. ornata*. (b) *P. ypsilychnus*. (c) *P. klunzingeri*. ALO, anterior light organ; AN, anus; D, duodenum; OE, oesophagus; PC, pyloric caeca; PLO, posterior light organ; R, rectum. (RNJ).

remaining rays; pectoral fin pinkish hyaline; pelvic fin reddish hyaline, with distal 1/4 of first two segmented rays black; caudal fin reddish hyaline, with black tips on outermost branched rays. Colours from photographs of live individuals very similar to those of holotype, except for the following (Figs. 2,3; Allen, 1985: fig. 229; Gomon, 1994: fig. 536; unpublished photos by R. Kuiter): body background pale or cream-coloured, the posterior body and caudal peduncle sometimes transparent; stripe behind eye bright yellow or golden-brown; iris bright yellow; lower part of cheek with scattered yellow



**Fig. 5.** Line drawing of *Pempheris ornata* n.sp., AMS. I.20221-002, 58.5 mm SL, Mondrain Island, Recherche Archipelago, Western Australia. (RNJ).

chromatophores; body stripes much brighter yellow; fins usually less reddish with less obvious black tips.

In 70% ethanol: cheek, opercle, and area below pectoral fin and sometimes lower part of abdomen silvery; dorsal part of head and nape dusky; remainder of body straw-coloured; stripes present as series of dark chromatophores, sometimes only 6 (rather than 7) from ventral abdomen to dorsal-fin base; fins yellowish with similar pattern of dark tips as described above, although black coloration variable in extent; black, silver-margined, linear light organ associated with rectum visible through body wall (Fig. 5), becoming slightly bifurcate around anus.

**Comparisons.** The only species with vaguely similar coloration to *P. ornata* are *P. multiradiata* and colour forms of what is presently referred to as *P. oualensis*. In these two species the longitudinal stripes are brown

or reddish-brown (vs. orange or yellow) and more numerous (8 or more on the body vs. 6–7). Within the genus, *P. ornata* has uniquely low counts of lateral-line scales (32–39) and anal-fin rays (27–30). *P. multisquamata* has the lowest lateral-line scale counts among remaining *Pempheris* species (42–49). Only *P. analis* and the new species *P. ypsilychnus* overlap the uppermost portion of the anal-fin ray count (30–36); both of these species have ctenoid (vs. cycloid scales), lateral-line scale counts of well over 60, and are without any longitudinal striping.

**Distribution.** Specimen localities are limited to areas along the southwest and south coast of Australia, from Rottnest Island (near Perth) to Rapid Bay (just south of Adelaide) (Fig. 6). The species also has been reported north to Dongara (= Port Denison), Western Australia (Hutchins & Swainston, 1986; Hutchins, 1994).

**Table 1.** Total number of gill rakers on the first arch of specimens of *Pempheris ornata* n.sp. from western (Rottnest Island, Recherche Arch.) and eastern (Kangaroo Island, Rapid Bay) localities.

No. of Gill Rakers	28	29	30	31	32
Western localities	2	4	5	5	1
Eastern localities	8	5	4	–	–

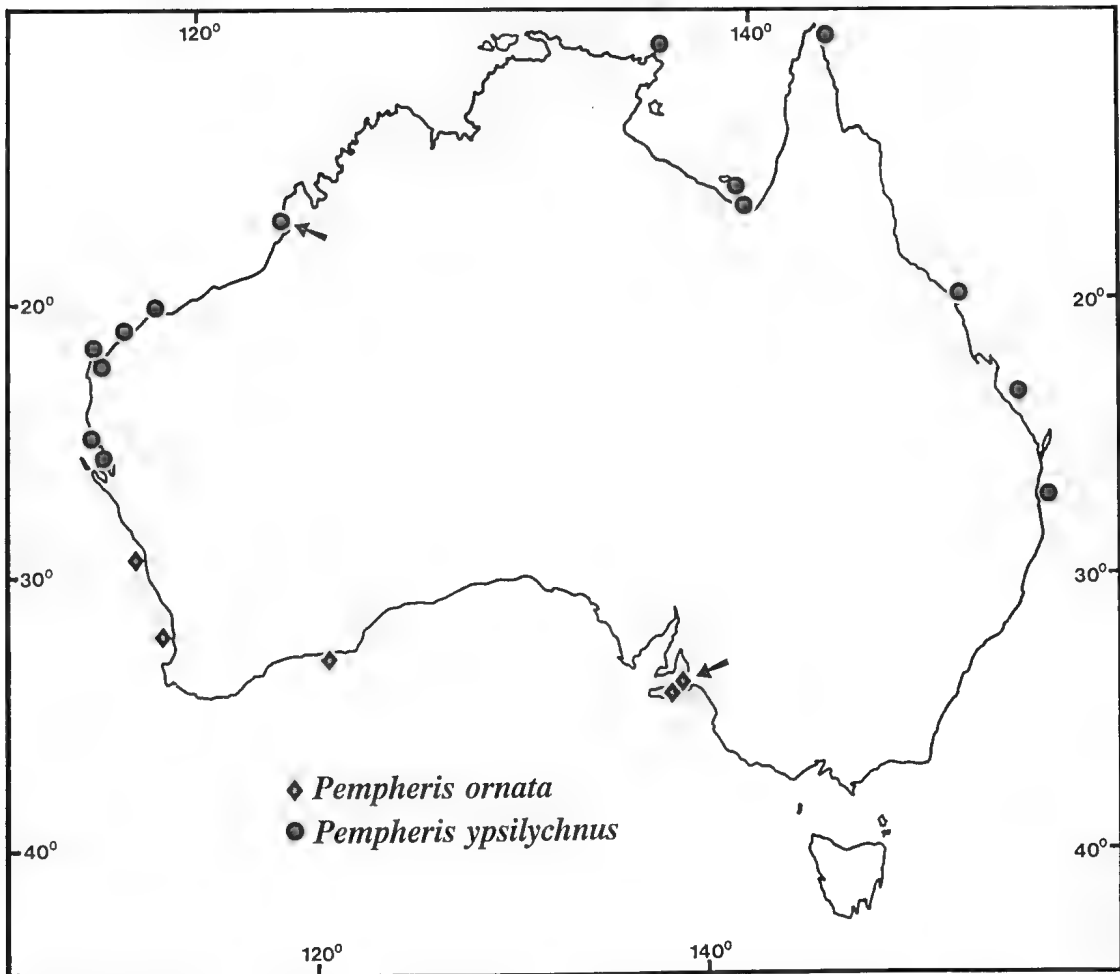


Fig. 6. Distributions of the two new species of *Pempheris*. Arrows indicate holotype localities.

**Biology.** The species is reported as sometimes congregating beneath piers and near jetties and not often sighted during the day (Gomon, 1994). The deepest recorded collecting site is 30 m. This is the smallest member of the genus *Pempheris*, not known to exceed much more than 75 mm SL. The smallest gravid female measured 56 mm SL. The only geographic difference in meristics noted was a slightly lower total number of gill rakers on the first arch for the easternmost collections (Kangaroo Island, Rapid Bay) compared to western collections (Rottnest Island, Recherche Arch.) (modes of 28 vs. 30–31) (Table 1). However, more specimens are needed to establish whether or not these differences are significant.

**Etymology.** The specific name comes from the Latin *ornamentum*, meaning ornamented or ornate, in reference to the spectacular coloration of this species compared to its congeners. It is to be treated as a noun in apposition.

### *Pempheris ypsilychnus* n.sp.

Figs 4b, 6–8; Tables 2–3

*Pempheris analis* (non Waite, 1910).—Tominaga, 1963: 276, 278, tab. 4 (description of posterior light organ, meristics, distribution).—Tominaga, 1968: 72, 74–78, 80, 82, 86, tabs. 3–5 (descriptions of osteology, meristics, posterior light organ, and possible affinities).

*Pempheris klunzingeri* (non McCulloch, 1911).—Haneda *et al.*, 1966: 537, figs. 3,4 (description of light organ structure, drawings of anatomy).

*Pempheris* sp. 1.—Hutchins, 1994: 49 (Western Australian distribution).

**Material examined.** HOLOTYPE: WAM P.28059-019, 74.1 mm, Western Australia, Broome (17°59'S 122°11'E), 1 m, N.L. Sarti, 28 March 1982.

PARATYPES: 18 specimens, 51.5–117.7 mm. AMS I.15557-187, 7: 51.5–80.0 mm, Queensland, Gulf of Carpentaria (17°24'S 140°09'E), 10 m, CSIRO Prawn Survey, 27 November 1963; CSIRO C3443, 117.7 mm, Queensland, Gulf of Carpentaria (16°56.7'S 140°08.8'E), 18 m, Rama

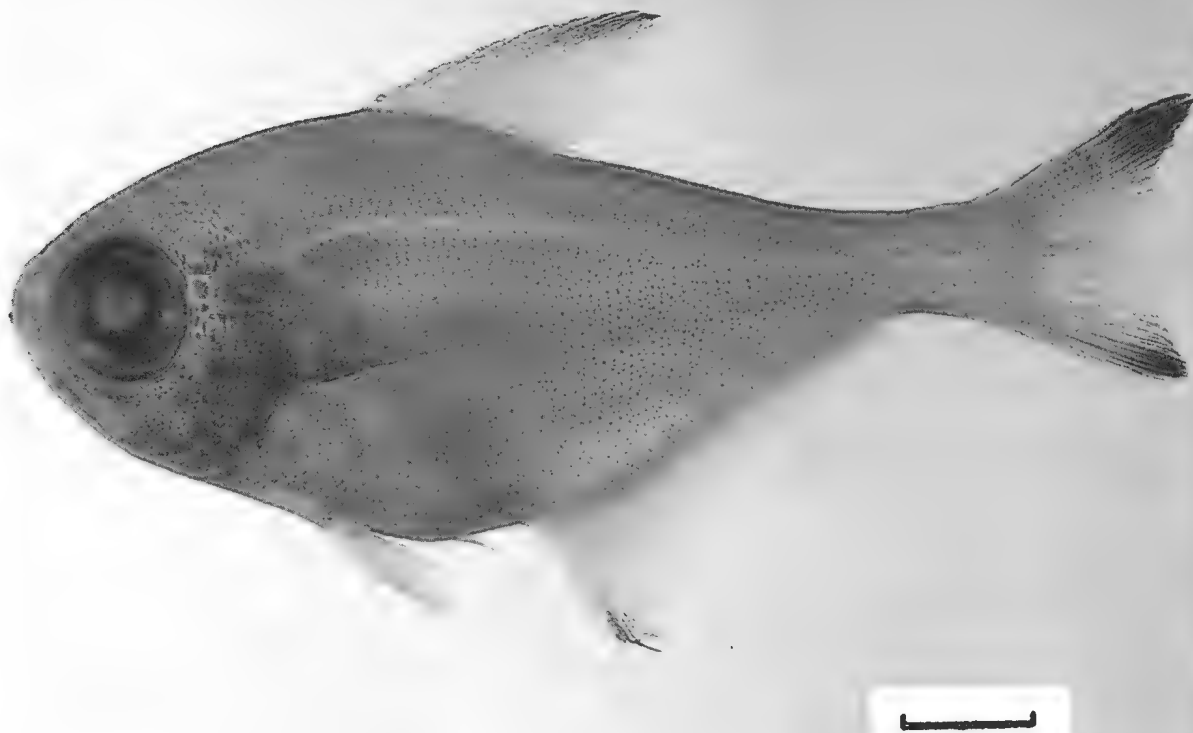


Fig. 7. Holotype of *Pempheris ypsilychnus* n.sp., WAM P28059-019, 74.1 mm SL, Broome, Western Australia, preserved in ethanol. Scale bar is 10 mm.

stn 147, 11 September 1963; MPM 31024, 4: 60.9–78.9 mm, from AMS I.15557-187; NTM S.13277-001, 88.5 mm, Queensland, east of Cape York Peninsula (11°21.4'S 142°58.2'E), 22 m, R. Williams, 1 December 1991; SMNS 14293, 2: 58.0–68.3 mm, Western Australia, Exmouth Gulf, 6–12 km south of Exmouth (22°00'00"S 114°08'30"E to 22°02'20"S 114°08'30"E), 11–14 m, R. Fricke and F/V "Denison", 2–3 September 1992; USNM 337546, 63.7 mm, from MPM 31024; WAM P.28059-023, 66.7 mm, collected with holotype; WAM P.28416-019, 91.2 mm, Western Australia, Gantheaume Pt. (17°58'S 122°10'E), 2–5 m, N. Sarti and A. Williams, 13 September 1982.

**Other material:** 44 specimens, 56.5–120.6 mm. AMS IA.1780-81, 2: 91.5–92.4 mm, Queensland, Port Denison (20°03'S 148°15'E), E.H. Rainford, 1924; AMS IB.7208, 65.0 mm, Queensland, Gulf of Carpentaria; AMS I.20769-045, 110.1 mm, Cape York, Halfway Island, NNW face (11°23'S 142°57'E), 4–9 m, AMS Australian Institute of Marine Science, 18 February 1979; AMS I.15482-005, 64.3 mm, Queensland, Heron Island (23°27'S 151°57'E), H. Choat, 16 June 1965; AMS I.15557-289, 8: 56.5–67.8 mm, Queensland, Gulf of Carpentaria (17°24'S 140°09'E), 10 m, CSIRO Prawn Survey, 27 November 1963; CSIRO C2640, 99.6 mm, Western Australia, Dampier Archipelago (20°35'S 116°35'E), Vessel Lancelin, 1954; CSIRO C2786, 95.2 mm, Western Australia,

Exmouth Gulf? (22°S 114°20'E), Vessel Lancelin; CSIRO C2787, 98.2 mm, as CSIRO C2786; CSIRO A3230, 110.7 mm, Queensland, Gulf of Carpentaria, SE of Mornington Island (16°42.2'S 139°29.5'E), 12.6 m, Rama stn 336, 11 November 1963; CSIRO A3231, 77.6 mm, as CSIRO A3230; CSIRO A3232, 72.5 mm, as CSIRO A3230; NTM S.13236-001, 84.0 mm, Northern Territory, south of Sphinx Head, Marchinbar Island (11°16'S 136°41'E), 18–21 m, H. Larson, 16 November 1990; WAM P.4317, 2: 77.3–81.5 mm, Western Australia, Dampier Archipelago (20°33'S 116°32'E), P. Barrett-Lennard, December 1957; WAM P.4687, 67.4 mm, Western Australia, Exmouth Gulf (22°05'S 114°15'E), 13 m (7 fthms), R. McKay, 13 September 1958; WAM P.13415, 72.8 mm, Western Australia, Dampier Archipelago (20°33'S 116°32'E), 1954; WAM P.13416-13421, 6: 113.8–120.6 mm, Western Australia, Shark Bay (25°21'S 113°44'E), F. Barrett-Lennard, September 1960; WAM P.13422, 68.2 mm, Western Australia, Exmouth Gulf (22°05'S 114°15'E), R.J. McKay, 13 September 1958; WAM P.13458, 58.9 mm, Western Australia, Exmouth Gulf (22°05'S 114°15'E), R. McKay, 1958; WAM P.22950, 103.8 mm, Western Australia, Kendrew Island, Museum Bay (20°29'S 116°32'E), B. Hutchins, 19 February 1973; WAM P.23659-001, 95.4 mm, Western Australia, Carnarvon (24°53'S 113°40'E), 24 m (dredging at 13 fthms), D. Heald, 19 July 1972; WAM P.25113-001, 95.3 mm, Western Australia, Dampier Archipelago, Kendrew Island (20°28'S 116°32'E), G.R. Allen, 6 November 1974; WAM P.25369-024, 6: 58.8–80.8 mm, Western Australia, North West Cape, Outer Reef, off

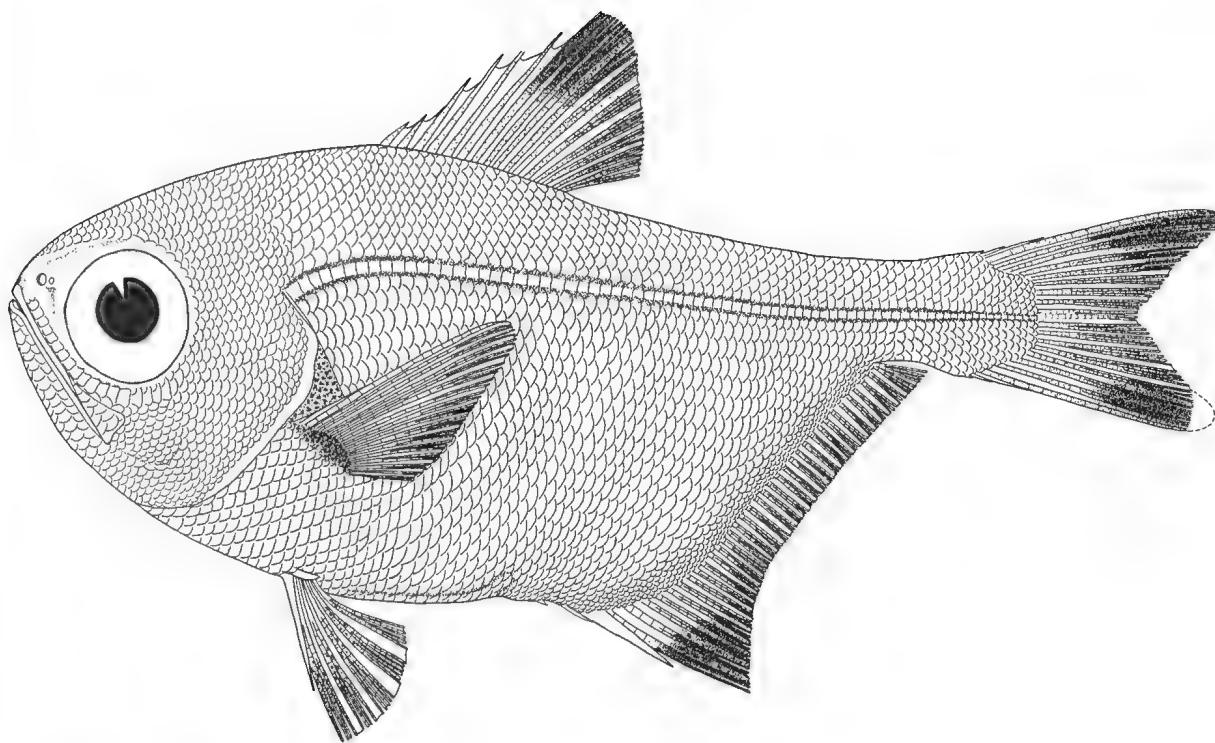


Fig. 8. Line drawing of *Pempheris ypsilychnus* n.sp., WAM P.13416, 113.8 mm SL, Shark Bay, Western Australia. (RNJ).

Tantabiddy Ck. (21°55'S 113°57'E), 8–10 m, G.R. Allen, 27 June 1975; WAM P.25508-017, 85.7 mm, Western Australia, Exmouth Gulf (21°57'S 114°12'E), B. Hutchins, 6–7 December 1975; WAM P.25508-051, 70.2 mm, Western Australia, Exmouth Gulf, 4 km from Exmouth (21°57'S 114°12'E), B. Hutchins, 6–7 December 1975; WAM P.26043-001, 92.7 mm, Western Australia, Shark Bay (25°25'S 113°25'E), P. Barrett-Lennard, 1960.

**Diagnosis.** *Pempheris ypsilychnus* is distinguished from all other members of the Pempherididae by the following combination of characters: all scales ctenoid and adherent; pelvic axillary scale present; lateral-line scales 62–74 (usually 63–69); gill raker counts on first arch 6–8 + 19–22 = 25–30 (usually 26–27); dark, Y-shaped light organ visible through body wall between pelvic- and anal-fin origins, with its bifurcation around anus (Fig. 8).

**Description.** Dorsal-fin rays VI,10 (VI,10; V–VI,9–11, V only once, rarely 11); anal-fin rays III,33 (III,34; III,30–36, once 30); pectoral-fin rays 17 (17; 16–18); pelvic-fin rays I,5; principal caudal-fin rays 9+8; upper procurrent rays 6,2 (6,2; 5–8,1–2); lower procurrent rays 3,2 (3,2; 3–5,1–2); lateral-line scales 64 (68; 62–74, rarely more than 70); scale rows above lateral line 9 (10; 9–11); scale rows below lateral line 18 (18; 17–21); cheek scale rows 7 (6–9, extremes less common); predorsal scales 39 (39; 35–45, usually 37–43);

circumpeduncular scales 22 (24; 22–26, usually 23–24); gill rakers 6+21 (7+20; 6–8, rarely 8 + 19–22); total gill rakers 27 (27; 25–30, most frequently 26–27, once 30).

As percentage of SL: head length 35.2 (34.5; 31.8–39.4); head depth 33.7 (34.0; 30.0–39.7); snout length 7.7 (7.0; 5.8–8.1); eye diameter 14.8 (15.1; 13.2–16.5); interorbital width 8.9 (8.0; 6.5–9.3); upper jaw length 19.0 (19.0; 17.3–20.5); predorsal length 41.0 (40.0; 36.1–44.7); prepelvic length 38.1 (38.7; 33.8–49.3); preanal length 57.8 (59.9; 54.0–66.1); pelvic-fin origin to anal-fin origin 22.5 (24.5; 19.8–29.6); body depth 43.8 (41.9; 37.1–46.0); pectoral-fin length 28.2 (27.9; 24.1–31.7); pelvic-fin length 19.2 (19.6; 17.4–21.8); dorsal-fin base 20.6 (20.3; 18.1–23.0); longest dorsal-fin ray 24.8 (24.3; 20.7–26.8); anal-fin base 43.1 (43.2; 40.5–46.0); longest anal-fin ray 19.8 (18.7; 15.0–21.7); caudal-peduncle length 12.0 (10.7; 9.0–13.0); caudal-peduncle depth 10.8 (10.5; 9.2–11.3); dorsal-fin origin to pelvic-fin origin 42.8 (41.5; 36.3–44.9); dorsal-fin origin to anal-fin origin 45.9 (45.3; 39.6–51.1); dorsal-fin origin to anal-fin insertion 57.9 (57.2; 43.9–60.9).

Caudal fin forked. All scales ctenoid and adherent. Gular scaled. Pelvic axillary scale present. Prepelvic area (breast) unkeeled, flat and broad.

Anterior and posterior light organs Y-shaped (Fig. 4b, 8). Anterior organ communicates with pyloric caeca, forward extension consisting of two ducts that unite anteriorly. Anterior organ underlain by pigmented tissue and layer of translucent muscle. Posterior organ

communicates directly with the rectum (Haneda *et al.*, 1966: 537), underlain by a layer of pigmented tissue.

**Coloration.** Live colour unknown. Holotype preserved in 70% ethanol (Fig. 7): dorsal part of head, nape, and body yellowish or straw and speckled with tiny dark brown chromatophores; cheek and particularly opercular area darker; preventral area anterior to pelvic-fin bases pale yellow and without chromatophores; dentaries without chromatophores, permitting dark bar on gular to show through; lower part of cheek dark; dark, Y-shaped light organ visible through body wall between pelvic- and anal-fin origins, with wide bifurcation around the anus, silvery margins along length of linear portion; iris black; lateral-line scales without chromatophores making lateral line obvious on lightly speckled body; dorsal fin hyaline, with, at most, distal 1/4 of spines and first three segmented rays dark; anal fin hyaline, with distal 1/4 of first two segmented rays dark; pectoral and pelvic fins hyaline; medial caudal-fin rays hyaline and speckled with tiny chromatophores, with bases yellow, three outermost branched rays and adjacent unbranched rays with black tips that gradually fade proximally. Colours of other preserved specimens very similar, differing in the following: variation in amount of black on tips of fins from none to 1/3 their length; occasionally silvery flanks; sometimes few or no chromatophores speckling body, sometimes more chromatophores, especially on ventral part of head; Y-shaped light organ often with silver margins over entire length; iris sometimes coppery.

**Comparisons.** In Australia, this species is most likely to be confused with *P. analis*, *P. compressa*, and *P. klunzingeri*. Among these ctenoid-scaled *Pempheris* species, only *P. ypsilychnus* bears a pelvic axillary scale and has a Y-shaped posterior light organ visible through the body wall (Fig. 8). It is the only member of the genus with a Y-shaped anterior light organ (Fig. 4b). Total gill raker counts for *P. ypsilychnus* are considerably lower than other ctenoid-scaled members of the genus (25–30 vs. 31–38). *P. klunzingeri* has the most similar body shape, but has five dorsal spines (vs. six) and a longer anal fin (anal-fin base:SL ratio 0.47–0.55, mean 0.51 vs. 0.41–0.46, mean 0.43) due to a higher number of segmented anal-fin rays (35–41 vs. 30–36); it also tends to have higher lateral-line scale counts (66–80, usually >70 vs. 62–74, usually 63–69) and the anterior light organ is restricted to a mop-like mass of tissue

communicating with the pyloric caeca (Fig. 4c). *P. analis* tends to be deeper bodied (dorsal origin to pelvic origin:SL ratio 0.41–0.46, mean 0.44 vs. 0.36–0.45, mean 0.42) with a longer anal-fin base (anal-fin base:SL ratio 0.43–0.49, mean 0.46 vs. 0.41–0.46, mean 0.43); additionally, it has no anterior light organ. *P. compressa* generally has higher numbers of segmented anal-fin rays (34–40 vs. 30–36) and, hence, a longer anal-fin base (anal-fin base:SL ratio 0.52–0.58, mean 0.54 vs. 0.41–0.46, mean 0.43); it has no anterior light organ.

**Distribution.** Specimens have been collected at a number of sites in northern Australia, from the central west coast of Western Australia to the southern Great Barrier Reef (Fig. 6). The southernmost record on the east coast, Moreton Bay near Brisbane, was reported by Haneda *et al.* (1966: 537) as *Pempheris klunzingeri* (a misidentification).

**Biology.** Little is known about this species. The largest known maximum size is 120.6 mm SL, and capture depths range from 1 m to 24 m. Haneda *et al.* (1966: 537) studied specimens obtained in a shrimp trawl, and described the anterior light organ as V-shaped, apparently overlooking the anterior portion of this structure (Fig. 4b). Body depth (measured as dorsal-fin origin to pelvic-fin origin) varies geographically. Specimens from western localities (Shark Bay to Broome) have deeper bodies than those from eastern localities (Gulf of Carpentaria to Port Denison) (0.40–0.45, mean 0.43 vs. 0.36–0.42, mean 0.40; means significantly different,  $T=6.79$ ,  $DF=60$ ,  $p<0.001$ ). Eastern specimens tend to have higher lateral-line scale counts and more segmented anal-fin rays than western specimens (Tables 2, 3); the higher anal-fin ray counts are particularly noticeable among Gulf of Carpentaria examples (Table 3).

**Etymology.** The specific name is a combination of *ypsilon*, the Greek letter Y, and *lychnos*, Greek for lamp or light. This combination alludes to the Y-shaped posterior organ that is visible through the body wall and characteristic of this species, reported to be luminescent (Haneda *et al.*, 1966). The epithet is to be treated as a noun in apposition.

**Discussion.** The relationships of these two new species cannot be determined at present. Preliminary results from a systematic revision of the family Pempheridae by the senior author, as well as the character distributions

**Table 2.** Number of lateral-line scales (left side) of specimens of *Pempheris ypsilychnus* n.sp. from western (Shark Bay to Broome) and eastern (Gulf of Carpentaria to Port Denison) localities.

No. Lateral-line scales	62	63	64	65	66	67	68	69	70	71	72	73	74
Western localities	2	1	6	6	7	6	2	1	1	–	–	–	–
Eastern localities	–	2	3	2	3	2	9	6	1	–	1	–	1

**Table 3.** Number of segmented anal-fin rays of specimens of *Pempheris ypsilychnus* n.sp. from western (Shark Bay to Broome) and eastern (Gulf of Carpentaria, Cape York and Great Barrier Reef) localities.

No. of anal-fin rays	30	31	32	33	34	35	36
Western localities	1	3	7	10	7	3	1
Cape York, GBR	—	2	2	1	1	—	—
Gulf of Carpentaria	—	—	1	1	8	10	4

described by Tominaga (1968) and Jubb (1977), provide reason to doubt the monophyly of the two included genera, *Parapriacanthus* and *Pempheris*. The two new species exhibit the external features that traditionally have been used to characterise *Pempheris* (deep body, anal fin in scaly sheath, lateral-line scales extending to posterior margin of caudal fin), but share a number of internal features with the members of *Parapriacanthus* (cleithrum morphology, Y-shaped anterior light organ in *Pempheris ypsilychnus*). Their placement in *Pempheris* should, therefore, be regarded as provisional.

Below is a key to the Australian species of *Pempheris*. In Australian waters, *Pempheris* can be distinguished from *Parapriacanthus* by: anal fin in scaled sheath (vs. no scaly sheath), 27 or more segmented anal-fin rays

(vs. 27 or fewer), lateral-line extending to distal tips of medial caudal-fin rays (vs. to middle of medial caudal-fin rays), deeper body (head length about equal to body depth vs. head length generally greater than body depth). The key is provisional in two respects. First, the membership of *Pempheris*, as noted, is subject to change until the genus can be diagnosed by synapomorphies. Second, the identification of species of cycloid-scaled *Pempheris*, excepting perhaps *P. schwenkii*, is questionable pending completion of a worldwide revision. Colour patterns noted below are those of adults. Distributions are taken from examined specimens and records in Hutchins (1994) and Hutchins & Swainston (1986). The authorship of *P. compressa* to White (1790) follows the recommendation of Paxton *et al.* (1989: 12).

#### Provisional Key to Australian *Pempheris*

1. Scales on flank cycloid and deciduous; lateral-line scales smaller than (and partly or mostly concealed by) surrounding scales, sensory tubes longer than wide or wider than long; prepelvic area narrow and keeled or broad and unkeeled ..... 2
- Scales on flank ctenoid and adherent; lateral-line scales equal in size or slightly larger than (and not concealed by) surrounding scales, sensory tubes wider than long; prepelvic area broad and unkeeled ..... 6
2. Dorsal fin V, 10–13; pelvic axillary scale absent; prepelvic area broad and unkeeled; lateral-line sensory tubes wider than long; anterior light organ present as mass of finger-like projections (Fig. 4c) ..... 3
- Dorsal fin VI, 8–10; pelvic axillary scale present; prepelvic area narrow and keeled; lateral-line sensory tubes longer than wide; anterior light organ absent ..... 5
3. Body with series of 6 or more longitudinal stripes; lateral-line scales 32–49; segmented anal-fin rays 27–39 ..... 4
- Body without longitudinal stripes; lateral-line scales 55–63; segmented anal-fin rays 37–43 (Australian endemic: Hervey Bay Qld. south to Montague Island, NSW) ..... *affinis* McCulloch, 1911



4. Body with 6–7 yellow or orange longitudinal stripes; lateral-line scales 32–39; segmented anal-fin rays 27–30; total gill rakers on first arch 28–32; posterior light organ linear with slight bifurcation around anus (Australian endemic: Dongara WA south and east to Rapid Bay SA; Fig. 5) ..... *ornata* n.sp.
- Body with 8 or more copper or brown longitudinal stripes; lateral-line scales 42–49; segmented anal-fin rays 32–39; total gill rakers on first arch 33–37; posterior light organ absent (Australian endemic: Jurien Bay WA south, through SA, Vic., Tas., north to Terrigal NSW) ..... *multiradiata* Klunzinger, 1880
5. Lateral-line scales 44–51; scales above lateral line 3–4; scales below lateral line 9–13; deep purplish dorsally, almost black posterior to dorsal fin, shading to silvery flanks with pinkish or lavender iridescence; leading edge of dorsal fin dark; scaled base of anal fin dark with remainder of fin pale or lightly pigmented; caudal fin dusky or yellow (widespread Indo-Pacific; in Australia, Rottnest Island, WA north, NT?, south to Capricorn Grp. Qld.) ..... *schwenkii* Bleeker, 1855
- Lateral-line scales 52–71; scales above lateral line 5–7; scales below lateral line 12–16; body generally coppery or silvery iridescent, sometimes with longitudinal stripes on body; leading edge of dorsal fin dark with black distal tips to anterior segmented rays; anal fin with or without dark base, remainder of fin dusky (or mostly dusky) except for pale distal margin; pectoral fin usually with distinctly dark base or spot (widespread Indo-Pacific; in Australia, Rottnest Island, WA north through NT?, south to Qld and Lord Howe Island, NSW) ..... *oualensis* Cuvier, 1831
6. Posterior light organ Y-shaped and visible through body wall; pelvic axillary scale present; total gill rakers on first arch 25–30; segmented anal-fin rays 30–36; anterior light organ Y-shaped (Fig. 4b) (Australian endemic: Shark Bay WA north through NT and south to Heron Island, Qld.; Fig. 5) ..... *ypsilychnus* n.sp.
- Posterior light organ absent; pelvic axillary scale absent; total gill rakers on first arch 31–38; segmented anal-fin rays 30–41; anterior light organ absent or a clump of finger-like projections (Fig. 4c) ..... 7
7. Dorsal spines V (first segmented ray branched); segmented anal-fin rays 36–41; in life, an orange bar behind head to pectoral base; anterior light organ present as a mass of finger-like projections (Fig. 4c) (Australian endemic: Shark Bay WA south and east to Kangaroo Island, SA) ..... *klunzingeri* McCulloch, 1911
- Dorsal spines VI (rarely V, if so, first segmented ray unbranched); segmented anal-fin rays 30–40; no orange bar behind head; anterior light organ absent ..... 8
8. Segmented anal-fin rays 34–40; body depth:SL ratio as measured from dorsal-fin origin to pelvic-fin origin 0.46–0.51, mean 0.49; anal-fin base:SL ratio 0.52–0.58, mean 0.54; dorsal fin with a dark leading edge, distal tips of only first or second ray dark; anal fin generally dark, without conspicuously darker tips to anterior rays (Australian endemic: Byron Bay NSW south to Gabo Island, SA) ..... *compressa* (White, 1790)

- Segmented anal-fin rays 30–36; body depth:SL ratio as measured from dorsal-fin origin to pelvic-fin origin 0.41–0.46, mean 0.44; anal-fin base:SL ratio 0.43–0.49, mean 0.46; dorsal fin with or without dark leading edge, distal third of first to fifth ray dark; tips of anterior anal-fin rays distinctly darker than other rays, other rays pale or pigmented (Jurien Bay WA north, through NT?, south to Broughton Island, NSW, east to Lord Howe Island; also Kermadec Island and North Island, New Zealand)..... *analis* Waite, 1910.

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## An Unusual Tasmanian Tertiary Basalt Sequence, Near Boat Harbour, Northwest Tasmania

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**ABSTRACT.** The mineralogy and petrology of basalts near Boat Harbour, NW Tasmania, are described as this sequence is unusual for Tasmanian Tertiary basalts. The rocks are more sodic and evolved basalts carry more prolific anorthoclase and zircon megacrysts than is normal in Tasmania. Older nephelinites and melilite-nephelinites (26–27 Ma) and younger nepheline hawaiites and mugearites (14–15 Ma) are present and fission track zircon ages (13–14 Ma and 8–9 Ma) demonstrate that zircon was erupted during and after the evolved basalts. The nephelinites and some evolved basalts carry common spinel ilmenite xenoliths, some with rare alkaline reaction veins. Crustal xenoliths are ubiquitous as Precambrian country rocks but include rare 2-pyroxene granulite and anorthosite. Some nephelinites show mariolitic assemblages of olivine, diopside-augite-aegirine clinopyroxenes, nepheline, sodalite, barian sanidine, ulvöspinel, titanian richterite, titanian phlogopite and carbonate.

The nephelinites and melilite nephelinite represent primary melts, while the evolved basalts can produce primary basanites by addition of a cumulate wehrlite mineralogy. However, crystal fractionation models for evolving these melts only give inadequate solutions. The low Zr contents, and presence of zircon and anorthoclase megacrysts do not fit into fractionation processes.

Nephelinitic geochemistry indicates 4–7% degrees of partial melting of an amphibole-dominated metasomatised garnet peridotite. Low H<sub>2</sub>O+CO<sub>2</sub> contents favour melilite nephelinite melt derived from deeper levels than for the nephelinite melts. Evolved basalts from such metasomatised sources may mark limited fractional crystallisation, while minor early initial melting may produce sodic Zr-rich felsic melts that crystallise anorthoclase and zircon without significant fractionation.

The rocks show an isotopic HIMU imprint, but unlike older east Tasmanian basalts lack trace element signatures related to the Tasman Balleny plume system.

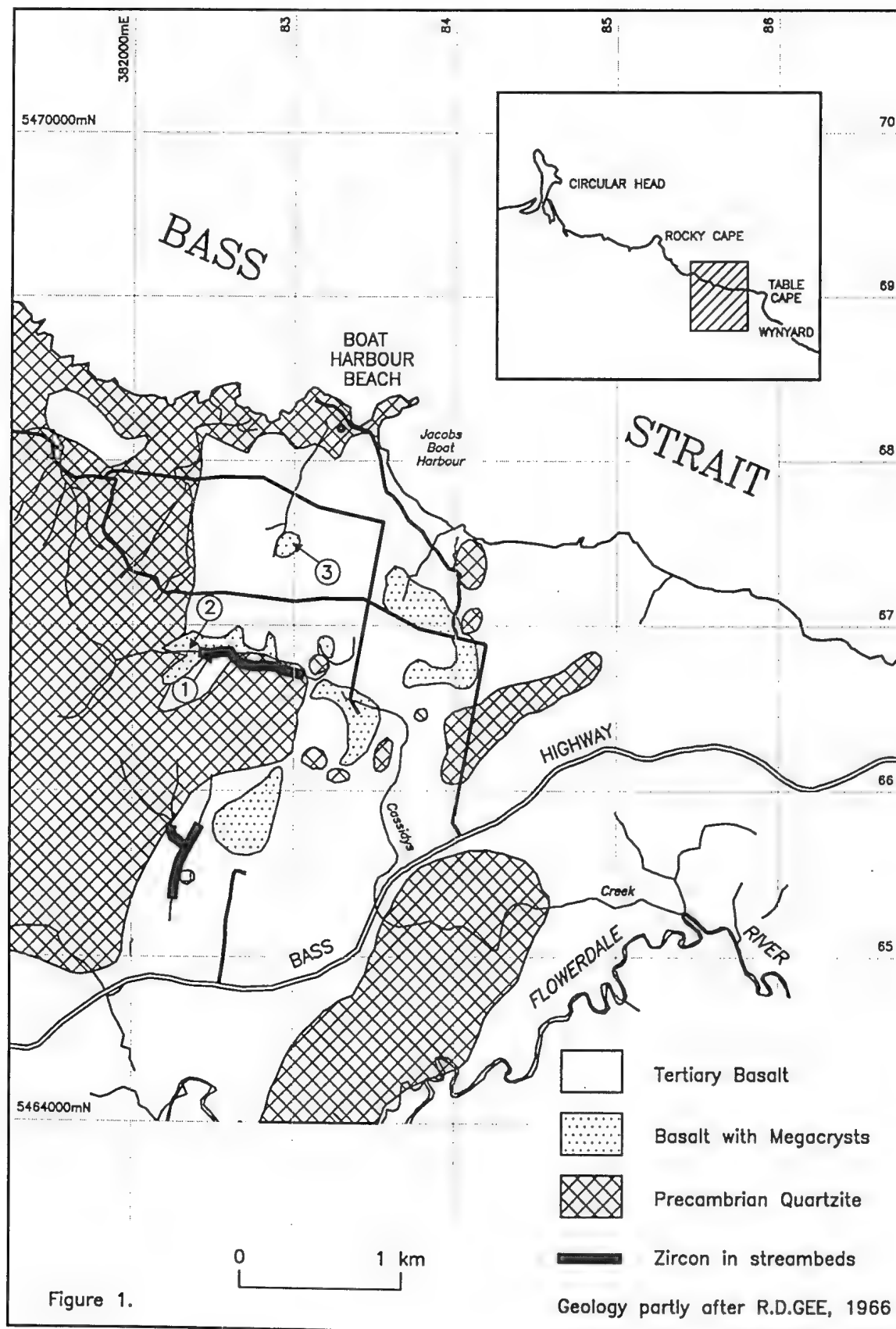


Fig. 1. Map of the Boat Harbour area showing distribution of zircon sites, basalts and basement rocks in the Cassidys Creek region. Circled numbers refer to dated sites: 1 zircon fission track site, 2. olivine melilite nepheline-olivine nepheline site, 3 nepheline mugearite site.

The Tertiary basalts exposed in Cassidys Creek near Boat Harbour, NW Tasmania, are unusual among Tasmanian sequences in containing:

- 1 Olivine melilite nephelinites and nephelinites at the same site
- 2 evolved alkaline basalts containing conspicuous anorthoclase megacrysts
- 3 gem zircon suites weathering from some evolved basalts.

The drainages that shed gem zircons from the basalt sequence include Cassidys and Sisters Creeks inland from Boat Harbour (Fig. 1). These creeks drain folded quartzose metasediments of the Proterozoic Rocky Cape Group and overlying Cainozoic gravels and basalts (Gee, 1971). The gem zircons are concentrated within alluvial deposits and were originally thought to come from sub-basaltic gravels, quartzites or a granitic source remote from the area (Matthews, 1973). However, their extraordinary abundance and many practically unabraded crystals suggest a local source (Hollis & Sutherland, 1985). Panning of heavy minerals from weathered, but *in situ* basalts in Upper Cassidys Creek (previously named Shekelton Creek) during this study confirmed a basaltic source for the zircons.

This study concentrates on the basalt sequence and the detailed gemmology, geochemistry and isotope dating of the zircons will be presented elsewhere.

### General Volcanic Setting

Volcanic sequences in this area are well exposed only in coastal cliffs between Boat Harbour and Wynyard to the east. Here, undated flows occupy valleys, some of which were filled with lavas before deposition of fossiliferous Late Oligocene/Early Miocene marine beds east of Table Cape (i.e. before 25–26 Ma; Sutherland & Wellman, 1986). These are largely alkaline basalts and some carry anorthoclase megacrysts (Geeves, 1982). Flow foot breccias and largely weathered flows overlie the Early Miocene marine beds east of Table Cape and are mostly alkali basaltic in character. Table Cape itself is a massive teschenite over 170m thick formed by differentiation of a basanite flow and contains abundant peridotitic mantle xenoliths towards the base and common pegmatitic schlieren in the upper parts (Gee, 1971; Geeves, 1982). This flow overlies basal vitric pyroclastics of olivine nephelinite composition, which carry a range of high pressure mantle and lower crustal xenoliths and megacrysts (Sutherland *et al.*, 1989). The Table Cape flow extends west towards Boat Harbour and was dated between 13–14 Ma (Sutherland & Wellman, 1986).

Inland, the extensive weathering with lateritic and red soil developments obscure the basalt relationships, apart from a few road cuts and landslip exposures. The Cassidys Creek zircon site, 1.75 km SW of Boat Harbour Post Office, yields fragments of several basalt types and only minor outcrops of flows. This may indicate a

breccia/dyke source related to a small eruptive centre. The Cassidys Creek rocks range from highly undersaturated to near primary nephelinitic compositions to more highly evolved basanites and nepheline hawaiites and mugearites. Some rocks contain mantle assemblages in their xenolith suites, others contain only crustal xenoliths. Zircons were recovered directly from two members of the nepheline hawaiite-mugearite suite.

### Basalt Sequence and Age Dating

Within the Cassidys Creek sequence, olivine melilite nephelinite and olivine nephelinite give the oldest ages (Late Oligocene 26.3–26.4±0.2 Ma ages; Sutherland & Wellman, 1986 and Table 1, Appendix). An evolved alkaline lava, with anorthoclase and zircon xenocrysts, yields a younger mid-Miocene age of 14.2±0.1 Ma (Table 1). The dated flow contains fresh phenocrysts, but the groundmass includes some alteration so that the K-Ar age may be slightly lower than the true age of extrusion. These rocks are capped on the north bank of Cassidys Creek by a distinct, blocky-jointed coarse basalt, which weathers into red soils. In petrography, this basalt resembles Table Cape teschenite dated at 13.3±0.2 Ma (Sutherland & Wellman, 1986) and yields no zircons from soils panned from its weathered top.

Zircons sampled from alluvial deposits below zircon-bearing basalts include prominent coloured crystals. These gave a fission track age of 13.9±0.7 Ma (Table 2, Appendix), supporting the mid-Miocene K-Ar age for the evolved lavas. Pale, rounded, small zircon grains, which contrast with the typical zircons, give lower uranium contents (30–281 ppm cf. 193–441 ppmU) and a younger fission track age of 9.5±0.6 Ma (Table 1). A similar age is recorded from basalt in northwest Tasmania (Baillie, 1986) and suggests such activity took place near Boat Harbour, although the source for these zircons is not yet identified.

The combined K-Ar and zircon fission track dating (Fig. 1; Tables 1, 2) indicates at least three eruptive episodes in the Cassidys Creek section.

- Late Oligocene nephelinitic activity (26–27 Ma)
- Mid-Miocene zircon-bearing evolved alkaline activity (14–15 Ma) and slightly evolved alkaline activity (13–14 Ma)
- Late Miocene zircon-bearing alkaline (?) activity (9–10 Ma)

### Analytical Procedures

Representative analyses were made of mineral phases in the basaltic rocks, their xenocrysts and xenoliths. They are presented in Tables 3–10 (Appendix) and summarised in triangular diagrams for pyroxenes (Fig. 2a), olivines (Fig. 2b) and feldspars (Fig. 3). Analyses were made by electron microprobe and two different instruments

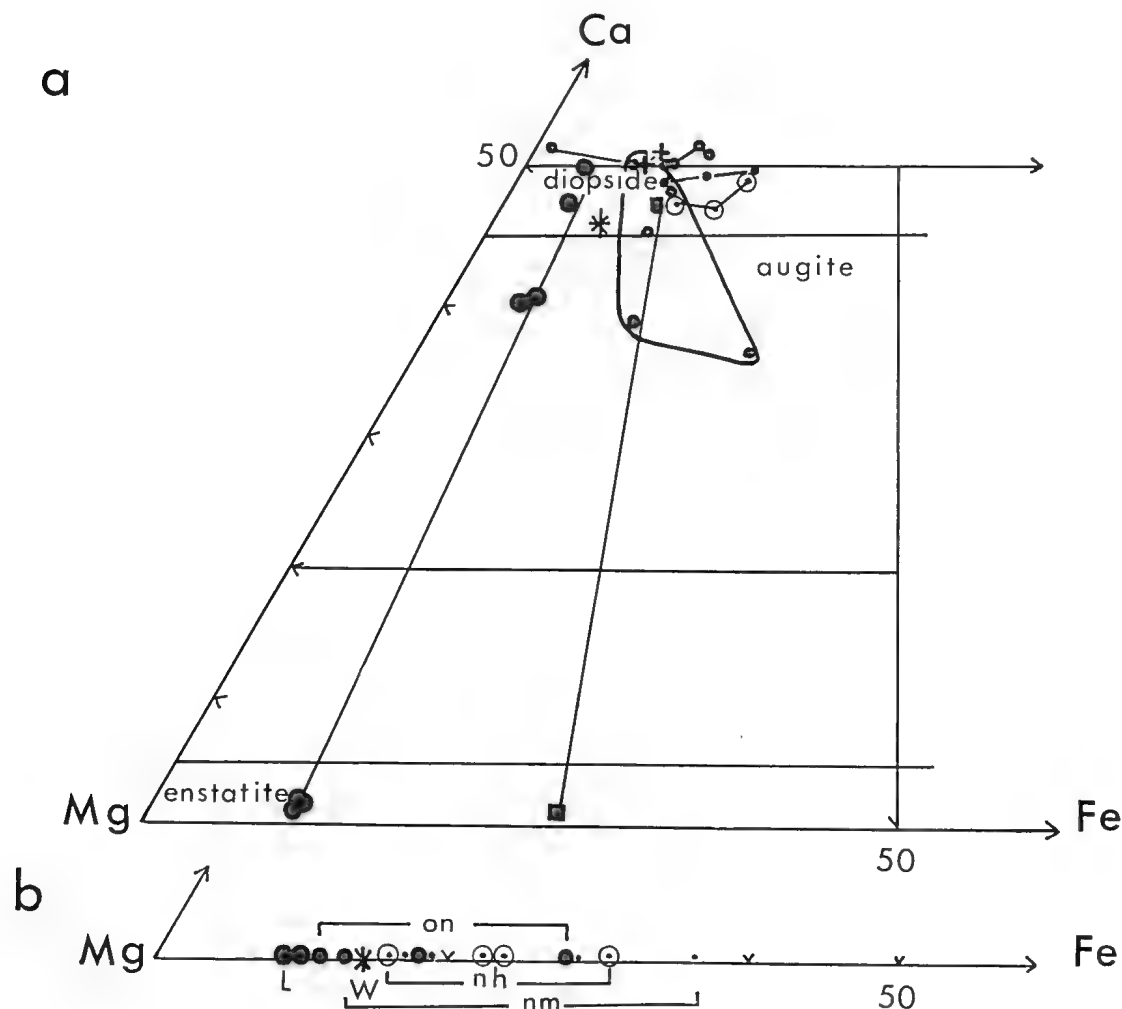


Fig. 2. a. Pyroxene compositions in Cassidy's Creek host rocks, segregations and xenoliths plotted in an Mg-Ca-Fe diagram. Olivine melilite nephelinite (crosses), olivine nephelinite (solid dots, with those of segregations enclosed in a field), nepheline hawaiiite (circled dots, with those of segregations joined by tie lines), nepheline hawaiiite (small dots), ilherzolite xenoliths and metasomatic replacements (solid large circles), wehrlite xenoliths (asterisk) and granulite xenoliths (solid squares). Two-pyroxene assemblages co-existing in xenoliths are joined by solid tie lines. Pyroxene nomenclature after Morimoto (1988). b. Olivine compositions Cassidy's Creek lavas and xenoliths. Olivine nephelinites (on) solid circles, nepheline hawaiiites (nh) circled dots, nepheline mugearites (nm) small dots, ilherzolite xenoliths (L) large dots, wehrlite xenolith (W) asterisk.

were used. Most analyses were obtained in a combined wave length/energy dispersive system at the Electron Microscope Unit, University of Sydney, with wave length spectrometers used to improve detection limits on key elements such as Na and K (D.F.H. analyst). Other analyses were made on an automated ETEC microprobe at Macquarie University, using natural standards, Bence-Albee matrix corrections and 15kV accelerating voltage (B.J.B. analyst). These methods yield precisions better than  $\pm 1\%$  for elements present at above 10wt% as oxide,  $\pm 5\%$  at 1–10wt% levels and  $\pm 10\%$  at levels below 1wt%. Comparative analyses from the two instruments usually agree within  $\pm 2\%$  for oxides over 5wt%, within  $\pm 8\%$  for oxides between 1–4wt% and  $\pm 30\%$  for oxides below 1wt%.

Bulk rock chemistry on the basalts was determined for major elements by X-ray fluorescence spectrometry, using fused borate button sample preparation, with Na determined by flame photometry and FeO determined by dissolution with HF in presence of ammonium metavanadate and titration against standardised ceric sulphate. These methods gave a precision around 0.6%. Trace elements were determined from pressed powder samples with boric acid bases, by X-ray fluorescence, using mass absorption data derived for major element analyses. Water and CO<sub>2</sub> determinations were made on most rocks, although some were made only as ignition loss.

The nomenclature of basalt types is based on the bulk chemistry given in Table 11 (Appendix) and follows the



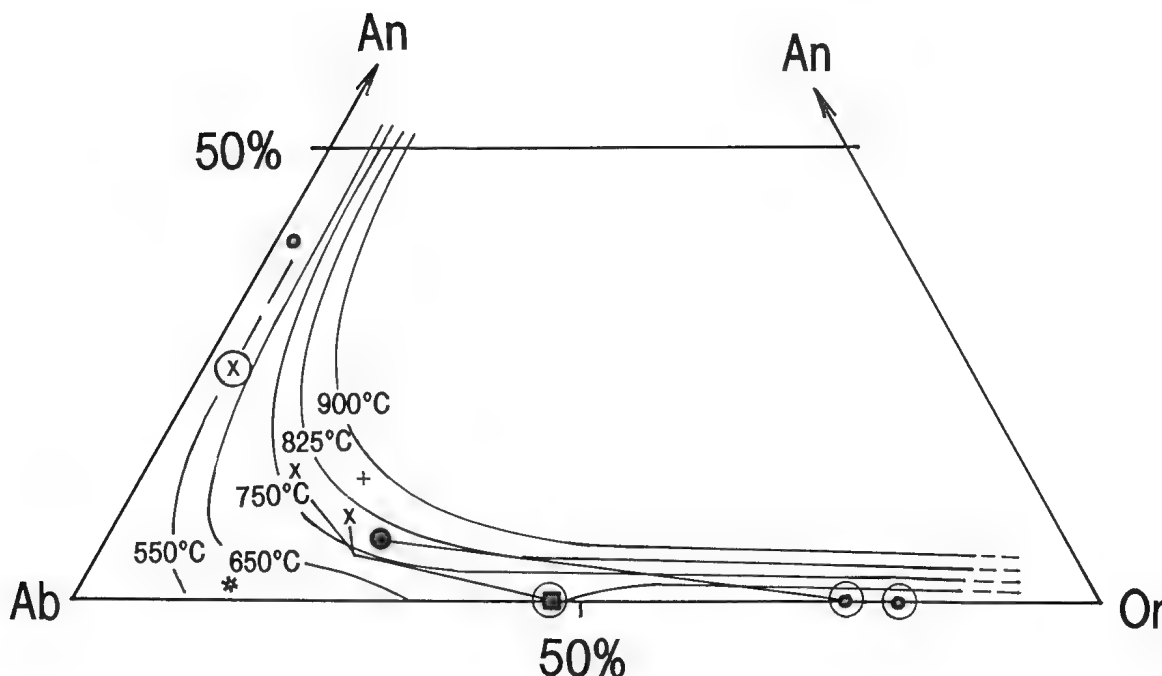


Fig. 3. Alkaline feldspar compositions (<50% An) for Cassidy's Creek groundmass, segregation, xenolith replacement, xenolith and megacryst phases plotted in an Ab-Or-An diagram. Anorthoclase; nephelinite groundmass (solid circle), nepheline hawaiiite segregation (inclined cross), nepheline mugearite (upright cross), megacryst (asterisk). Sanidine; nephelinite mariolite (solid centred circle), lherzolite replacement (solid square). K-oligoclase; anorthosite (circled cross), andesine-2pyroxene granulite (dot). Feldspars from related rocks are joined by solid lines. Temperature isotherms at 1000 bars come from the experimental work of Seck (1971), with equilibrium plagioclase-alkali feldspar compositions at 900°C and 500 bars connected by tie lines.

classification proposed for east Australian volcanic rocks by Johnson & Duggan (1989). Detailed petrographic descriptions of the basalts are given in Table 12 (Appendix).

### Basalt Types

The rocks include olivine±melilite nephelinites, nepheline hawaiiites and nepheline mugearites. The nephelinites and some mugearites contain mantle xenoliths along with crustal fragment suites, so represent magmas erupted from mantle depths. Other nepheline hawaiiites and mugearites only contain crustal inclusions or no obvious inclusions. This does not mean unequivocal eruption from crustal chambers, as it may involve selective sampling within the magmatic plumbing systems.

**Olivine melilite nephelinites** (Analysis 1, Table 11 and Sutherland *et al.*, 1989) have near-primary Mg numbers (0.67–0.68). Microphenocrystic olivine, melilite and ulvospinel appear with groundmass clinopyroxene, ulvospinel and feldspathoids, which include sodalite (Table 12). Melilite end member compositions range between 60–65% akermanite, 34–36% soda-melilite and 0–5% gehlinites and the nepheline includes 25–28% of the potassic kalsilite end member (Ewart, 1989).

**Olivine nephelinites** (Analysis 2, Table 11) show a primary Mg#(0.69). Olivine phenocrysts and diopside microphenocrysts appear with groundmass olivine, clinopyroxene, ulvospinel, nepheline and alkali feldspar. A glomeroporphyrite texture in which clinopyroxene contains inclusions of olivine and ulvospinel suggests an early crystallisation for these minerals.

Late segregations in the groundmass become richer in nepheline and alkali feldspar, accompanied by more Fe-enriched olivine, diopside, ilmenite, amphibole and mica. Rare ovoid mariolitic cavities contain coarse growths of these minerals and the presence of sodalite, hydrous phases and euhedral crystals projecting into the cavity suggest growth in volatile-rich, chlorine-bearing fluids. There are some overlaps in the crystallisation sequence of these late-growth minerals (Table 12), but the general paragenetic sequence is olivine, then diopside, amphibole, sodian augite, sodalite, nepheline, ulvospinel, sanidine, phlogopite and carbonate. In some variants clinopyroxenes lack olivine inclusions and contain resorbed cores and, in others, apatite is more abundant and mica is rare. These may represent more evolved residues.

**Nepheline hawaiiites** (Analyses 3, 6–7, Table 11) are moderately evolved rocks (Mg# 0.56–0.61). They range from aphyric to more porphyritic types.

Aphyric nepheline hawaiiite (Analysis 3) is rich in nepheline, accompanied by olivine clinopyroxene, alkali feldspar and ulvospinel. Microporphyritic nepheline hawaiiites (Analyses 6–7) show similar Mg#s (0.56–0.58) but contain anorthoclase and zircon xenocrysts and microphenocrysts of olivine and diopside. The groundmass includes plagioclase, nepheline, alkali-feldspar and ulvospinel (Table 7). Mariolitic cavities are infilled by diopside, anorthoclase, nepheline and ulvospinel and amygdaloids by zeolites.

The aphyric nepheline hawaiiite (Mg# 0.58) and Table Cape-nepheline hawaiiites (Mg# 0.61) are lower in SiO<sub>2</sub> but higher in MgO and CaO than the porphyritic types which are enriched in alkalis (cf. Analyses 3 & 4 with Analyses 6–7).

**Nepheline mugearites** (Analyses 5, 8–9) show Mg#s (0.57–0.60) similar to the nepheline hawaiiites, but normative An% is lower (<30%) reflecting more alkaline compositions. They also carry anorthoclase and zircon xenocrysts and typically contain microphenocrysts of olivine and clinopyroxene in a groundmass of olivine, clinopyroxene, ulvospinel, nepheline, alkali feldspar and yellow glass (Table 6). Some show abundant apatite inclusions in the late alkali feldspar and thin feldspathic segregation veins.

### Xenocrysts

Most xenocrysts are derived from the typical xenoliths suites found in the rocks. However, a few distinctive xenocrysts are present.

**Anorthoclase** is prominent in several evolved lavas, both in the mantle and crustal xenolith-bearing types. Crystals range up to a few centimetres across and show resorbed margins. Restricted core compositions (Table 6) fall in the sodian anorthoclase range (Ab<sub>82-84</sub> Or<sub>13-15</sub> An<sub>3-4</sub>) and are more sodian than groundmass and late segregation anorthoclase within the host rocks.

**Zircon** includes hafnium and thorium-bearing examples (Hf 1.1wt% and Th 0.2wt%; Hollis *et al.*, 1986) and uranium may exceed 440 ppm (Table 1). A feature of the zircon is rare earth patterns that lack europium depletion (Sutherland, 1996). This does not support its crystallisation from evolved basaltic liquids, so the zircons are true xenocrysts in relation to their hosts. More detailed investigations of the zircons will be presented elsewhere.

**Olivine** in one nepheline mugearite, includes olivine that is too magnesian (Fo<sub>90-91</sub>) to relate to the host (olivine phenocrysts Fo<sub>81</sub>) or to disaggregated spinel wehrlites (olivine Fo<sub>85</sub>) in the rock (Table 9). The olivine is simply twinned and thinly rimmed by olivine crystallised from the host. The Ca content (0.1wt%) may indicate a high temperature basaltic

origin rather than disintegration of mantle lherzolite, in which olivines show CaO under 0.1wt% (Ewart, 1989). Enstatite (En<sub>89-90</sub>) xenocrysts in the rock in contrast shows compositions and reaction rims typical of disaggregated mantle lherzolites.

### Xenoliths

Mantle xenoliths are dominated by spinel lherzolites, but one nepheline mugearite also carries rare wehrlite besides lherzolites. Crustal xenoliths include common quartzitic metasediments, and rare granulites and anorthosites.

**Spinel lherzolites** (Table 8) contain anhedral olivine (Fo<sub>89-91</sub>) up to 5mm across, intergrown in metamorphic textures with diopside (Wo<sub>37-38</sub> En<sub>57-58</sub> Fs<sub>5-3</sub>), enstatite (En<sub>88-89</sub> Fs<sub>9-10</sub> Wo<sub>1-2</sub>) and interstitial chromian spinel (Sp<sub>78-84</sub> Cm<sub>10-17</sub>). Xenoliths range from pristine to partially altered. These assemblages give re-equilibration temperatures around 900–920°C based on Cr-Al-orthopyroxene thermometry (Witt-Eicksen & Seck, 1991). This correlates with mantle pressures between 8–9kb (around 30 km depth) when projected on to the nearby Table Cape Tertiary geotherm (Sutherland *et al.*, 1989).

Infiltration and reaction occurs along grain boundaries giving incipient alteration of pyroxenes and replacing chromian spinel by rims of opaque oxide. Greater reaction with pyroxenes creates embayments and invasions of glassy melt. This melt has a hydrous, potassic intermediate-siliceous composition (Table 8), with normative compositions akin to that of magnesian “minette” (cf. Rock, 1991). This suggests introduction of K-rich fluids into the fresh lherzolite, which shows no potassic phases. Glasses are recorded from incongruent melting in lherzolite (Francis, 1987), but their compositions are higher in Si, Al, Ca, Na and lower in K and volatiles than the Cassidy's Creek glass. The latter resembles glasses linked to metasomatic infiltrations of lherzolites under both mantle and crustal pressures (Francis, 1991; Hornig & Wörner, 1991; Draper, 1992). It best fits reaction of lherzolite with alkaline K-rich and volatile-rich fluids represented by the sanidine, phlogopite and carbonate crystallisation in late segregations in the host basalt.

Under extreme reaction and melting, the lherzolite grains become completely replaced by a finer grained mineral assemblage (Table 8). Reaction with chromian spinel mainly replaces Al by Si, probably reflecting incipient spinel-feldspar reaction. Melt recrystallises into olivine (Fo<sub>89</sub>) sodian and chromian augite (Wo<sub>34</sub> En<sub>61</sub> Fs<sub>5</sub> containing up to 6% acmite and 2% jadeite end members), soda sanidine (Ab<sub>52-54</sub> Or<sub>46-48</sub>) and minor opaque oxide.

**Spinel wehrlite** (Table 8) contains coarse (up to 6mm) aluminian, sodian diopside (Wo<sub>36</sub> En<sub>60</sub> Fs<sub>4</sub>) containing 13% of the jadeite end member. It is intergrown with olivine (Fo<sub>85</sub>) and pleonaste (Sp<sub>79-80</sub> Hc<sub>15</sub> Mt<sub>4-5</sub>) in grains

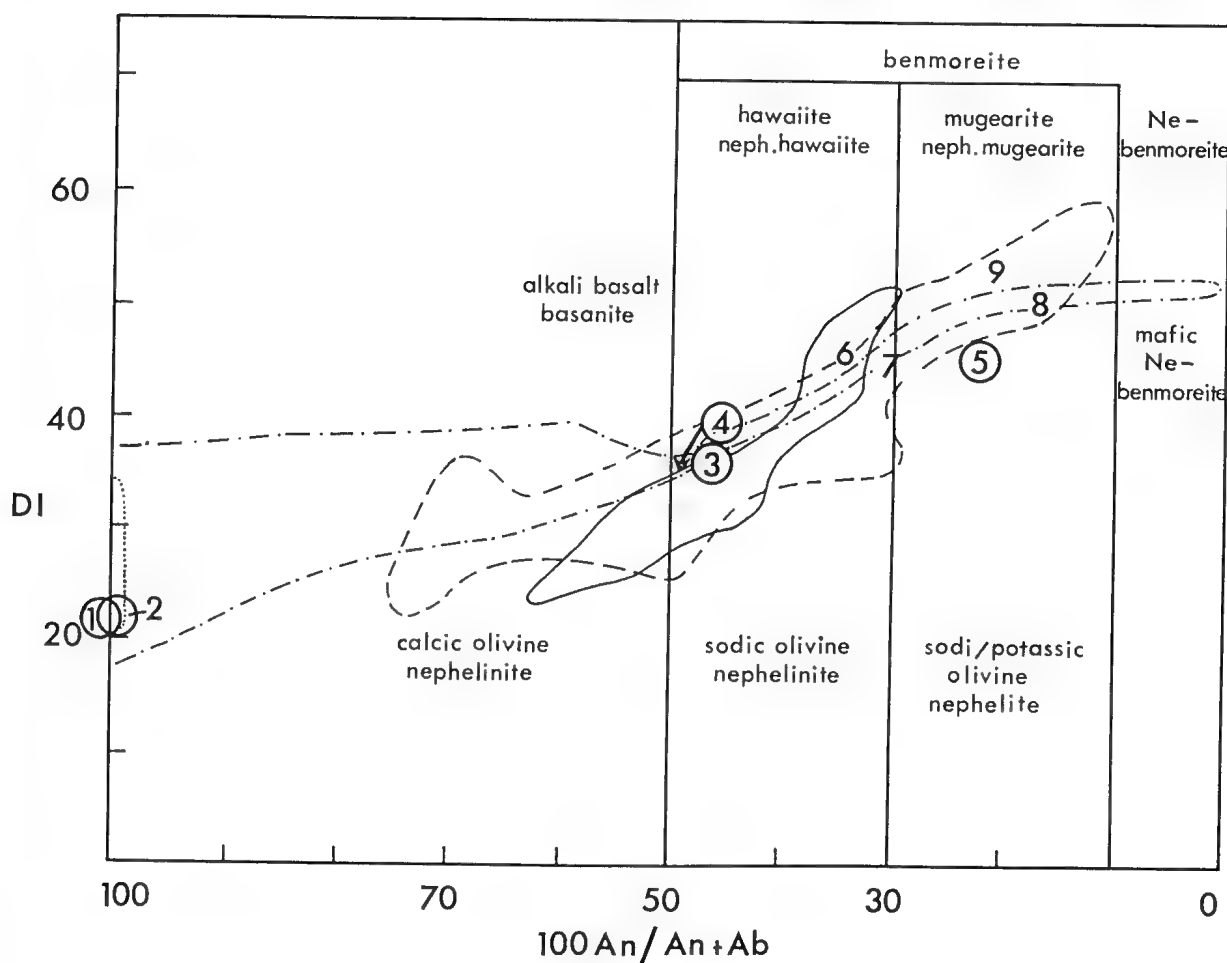


Fig. 4. Differentiation Index (D.I.) against  $100 \text{ An}/\text{An}+\text{Ab}$  (Analyses 1–9), Cassidys Creek-Table Cape volcanic rocks related to Tasmanian basaltic fields. Lherzolite-bearing rocks are circled. Tasmanian olivine melilite nephelinite (dotted line), olivine nephelinite lineage (dot-dashed line), basanite lineage (dashed line), alkali basalt lineage (solid line).

up to 4.5 mm across. The texture suggest a cumulate assemblage. Comparisons of the mineral compositions with those from mantle xenocrysts and the phenocrysts in the host nepheline mugearite (Table 8) supports a high pressure mantle origin from fractionating basanitic magma (Sutherland *et al.*, 1984; Griffin *et al.*, 1984).

**Quartzitic metasediments** show fragments rimmed by or completely fused into brown glass, with incipient developments of new minerals.

**Granulites** include two-pyroxene assemblages (Table 10) in which enstatite ( $\text{En}_{72-73} \text{Fs}_{27-28} \text{Wo}_{0.1}$ ), and diopside ( $\text{Wo}_{42} \text{En}_{46-47} \text{Fs}_{11-12}$ ) show irregular triple point intergrowths with abundant andesine ( $\text{Ab}_{56-61} \text{An}_{36-39} \text{Or}_{2-7}$ ). Re-equilibration temperatures (Wells, 1977 and Wood & Banno, 1973 thermometry) range between 860–880°C and when projected onto the Tasmanian Tertiary geotherm (Sutherland *et al.*, 1989) suggest re-equilibration pressures around 7kb, equivalent to about 25km depth.

**Anorthosites** (Table 10) contain andesian zoned from less sodian cores ( $\text{Ab}_{70-71} \text{An}_{26-27} \text{Or}_{3.4}$ ) to more sodian rims ( $\text{Ab}_{71-75} \text{An}_{20-25} \text{Or}_{3.4}$ ). Some grains show reaction coronas around quartz, where infiltrating fluids melted boundaries into siliceous glass containing indeterminate iron oxides, aluminosilicates and skeletal sanidine ( $\text{Ab}_{49-51} \text{Or}_{49-51}$ ). The texture suggest feldspar accumulation around quartz grains by magmatic reaction rather than a granulitic origin.

### Geochemistry of Basalts

**General features.** The sequence (Analyses 1–9, Table 11) is consistently ne-normative and sodic with only minor variations in  $\text{Na}_2\text{O}/(\text{Na}_2\text{O}+\text{K}_2\text{O})$  ratios (0.68–0.78) with changes in Differentiation Index (D.I. 20–55), normative  $\text{An}/(\text{An}+\text{Ab})$  (0.17–1.00),  $\text{Mg}/(\text{Mg}+\text{Fe}^{2+})$  (0.56–0.70) and  $\text{Al}_2\text{O}_3/(\text{CaO}+\text{Na}_2\text{O}+\text{K}_2\text{O})$  (0.44–1.03). However, there is a clear separation between the primary nephelinites and more evolved alkali basalts in D.I. versus  $\text{An}/(\text{An}+\text{Ab})$  plots (Fig. 4). In normative olivine-

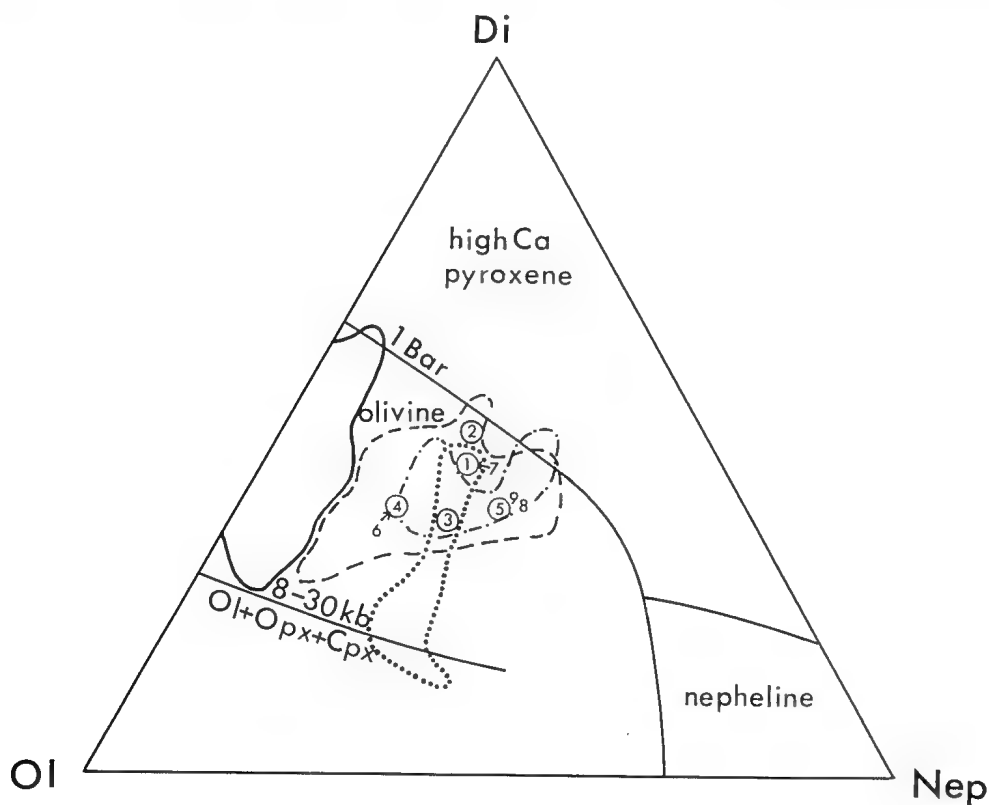


Fig. 5. Normative olivine (Ol)-nepheline (Nep)-diopside (Di) diagram showing plots of Cassidy Creek volcanic rocks (Analyses 1-9) relative to Tasmanian olivine melilitite, olivine nephelinite, basanite and alkali basalt lineages (fields as for Fig. 4). The cotectic experimental 1 bar and 8-30kb lines are after Sack *et al.* (1987).

diopside-nepheline diagrams, the primary nephelinites tend to higher D.I. values, but otherwise the field forms a relatively coherent group (Fig. 5). There is little separation between mantle and crustal xenolith bearing rocks in relation to the 1 and 8-30kb (ol+opx+cpx) cotectic projections (Sack *et al.*, 1987). This suggests magmas evolved at deeper crust/upper mantle levels, without extreme shallow crust modification.

**Minor and trace element features.** Among the minor elements Ti and K show contrasting trends. Ti decreases with evolution i.e.  $\text{TiO}_2$  2.8-3.3% for nephelinites, 2.3-2.5% for nepheline hawaiites and 1.6-1.8% for nepheline mugearites. K increases with more evolved character, i.e.  $\text{K}_2\text{O}$  1.1-1.3% for nephelinites, 1.9-2.1% for mantle xenolith-bearing nepheline hawaiites and 2.1-2.4% for nepheline hawaiites and nepheline mugearites. These trends no doubt involve differences in sources and melting for the magmas, but fractionation of phases in the evolved magmas probably played a part.

Crystallisation of phases, such as those in the spinel wehrlite cumulates dominated by titanian and sodian calcic clinopyroxene, would diminish  $\text{TiO}_2$  and CaO and augment  $\text{K}_2\text{O}$ , as observed in the evolved rocks. Distinctly higher P is present in the more undersaturated rocks i.e.  $\text{P}_2\text{O}_5$  1.2-1.6% below 43wt%  $\text{SiO}_2$  and  $\text{P}_2\text{O}_5$  0.8-

0.9% in rocks above 43wt%  $\text{SiO}_2$ . No apatite fractionation is obvious in the sequence, so this may reflect a source melting characteristic.

Compatible trace elements (Ni, Cr, V, Co, Sc) show depletion with decreasing Mg# (Fig. 6) typifying fractionation involving magnesian minerals. However, there is little increase in incompatible elements such as Zr expected in typical fractionation (Fig. 7). The Zr contents show no significant variation with change in Mg# or D.I. (Fig. 8). Zr and Nb show positive correlation, but the range in Zr contents and Zr/Nb ratios differ between the nephelinites (Zr 370-452 ppm, Zr/Nb 3.7-3.9) and evolved basalts (Zr 201-430 ppm, Zr/Nb 4-5). This reinforces the separate origin of these rocks shown by age dating.

Available compatible trace elements, normalised to primitive mantle values, are compared in Fig. 9. The nephelinites show the greatest incompatible enrichments except for K and Sr in some instances. Most evolved basalts are characterised by Rb, Ba and Nd depletions, except for some nepheline mugearites with high Ba. Remaining trace elements show little coherent change across the suites, except for Th and Pb which peak in the olivine melilitite nephelinite and Cu which decreases relative to Zn in the evolved basalts.

At least three trace element groups are found in the Cassidy Creek suites.

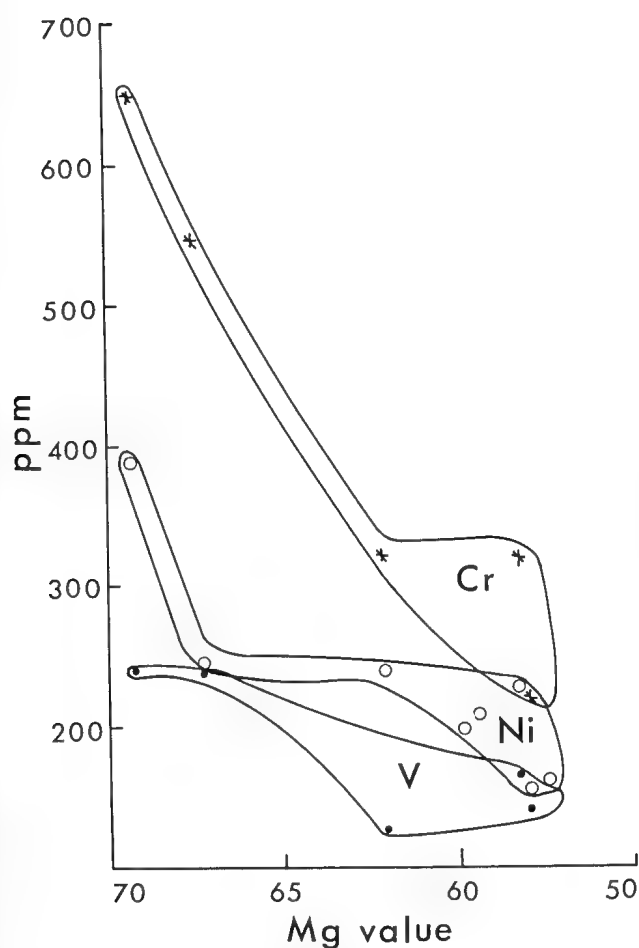


Fig. 6. Cassidys Creek compatible trace elements values (ppm), plotted against Mg value (Table Cape excluded). Chromium (stars), nickel (open dots), vanadium (dots). Analyses 1-3, 5-9.

1. Nephelinites with low Zr/Nb (3.7-3.9), Sr/Ba (2.5-4.2) and Rb/Nb (0.19-0.25) and high Ba/Rb (10.4-22.4);
2. Nepheline hawaiites and mugearites with higher Zr/Nb (4.0-5.0), Sr/Ba (13.7-22.5) and Rb/Nb (0.21-0.33);
3. Nepheline hawaiite and mugearites with significantly lower Sr/Ba (4.85-5.5) and higher Ba/Rb (11.8-15.0) than in the other evolved rocks.

In general, Zr/Nb ratios increase with degree of partial melting of mantle sources that generates the olivine melilitite-tholeiite petrogenetic spectrum (Frey *et al.*, 1978). This can be represented by plotting Zr/Nb against (ne+lc) for the undersaturated members (Fig. 10), after Green (1992). The higher Zr/Nb for the evolved lavas is consistent with a higher degree of source melting than for the nephelinites, and implies a basanitic parent magma may be involved.

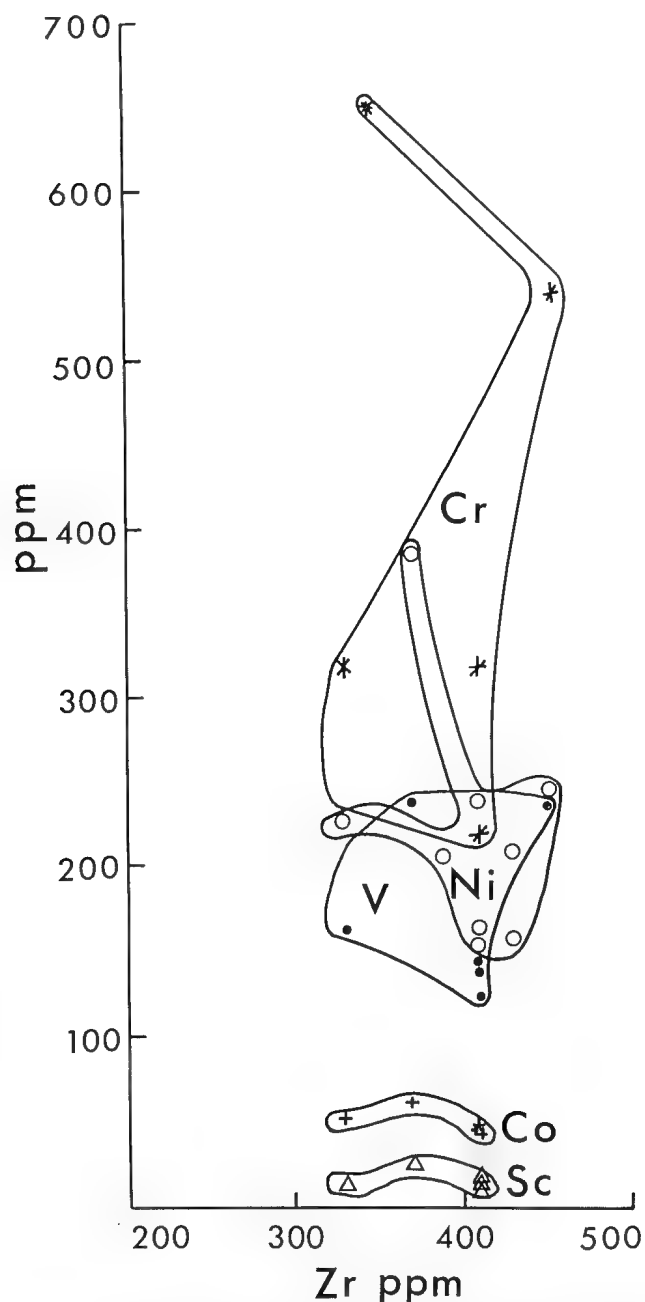
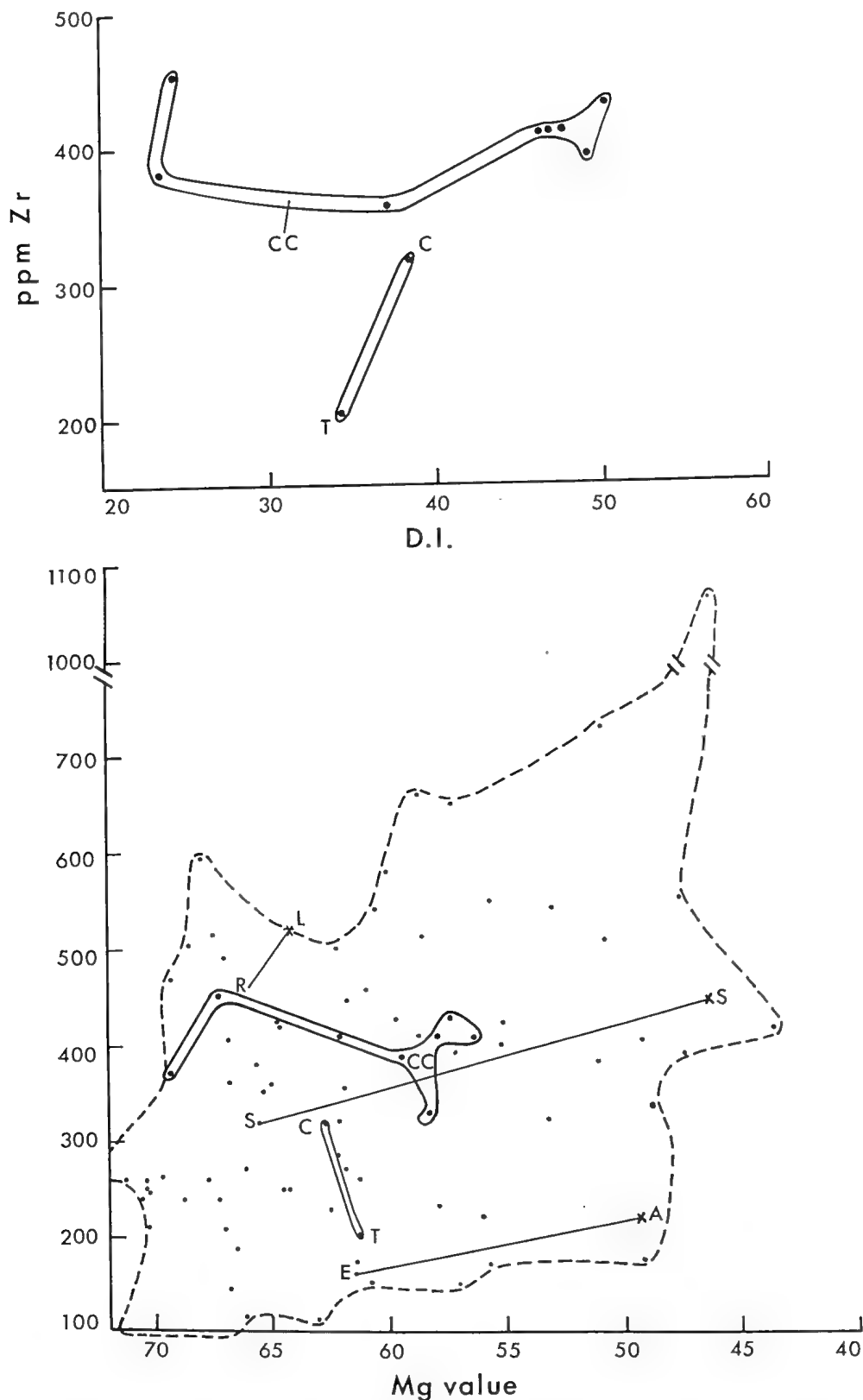


Fig. 7. Cassidys Creek compatible trace element values (ppm), plotted against Zr (ppm). Cr, Ni and V fields as for Fig. 6, with Co (crosses) and Sc (triangles).

### Origin and Evolution of the Magmas

The high Mg# and low Zr/Nb for the nephelinites typify primary low degree partial melts that retain inputs from their source conditions, whereas the lower Mg# and higher Zr/Nb for the evolved lavas typify modified magmas in which source inputs become masked.

**Primary Sources for nephelinites.** The co-existence of both melilitite-bearing and normal nephelinites at the one site, has relevance to likely source conditions. Such



**Fig. 8. a** (above): Zr trace element contents plotted against D.I.: Cassidys Creek field CC, Table Cape field TC. Analyses 1–9 and F.L. Sutherland, unpublished data. **b** (below): Zr (ppm) values plotted against Mg values for Cassidys Creek (CC) and Table Cape (TC) fields, in relation to values plotted for other Tasmanian basalts; data from Frey *et al.* (1978), Everard (1984, 1989) and Sutherland (1984, 1985, 1989a and unpublished). Host and late-stage pegmatoid trends are joined by tie lines for Round Lagoon olivine nephelinite (RL), South Scottsdale olivine nephelinite (SS) and East Arm basanite (EA). The Sandy Bay mafic nepheline benmoreite plot is off scale and shown as a discontinuous value.

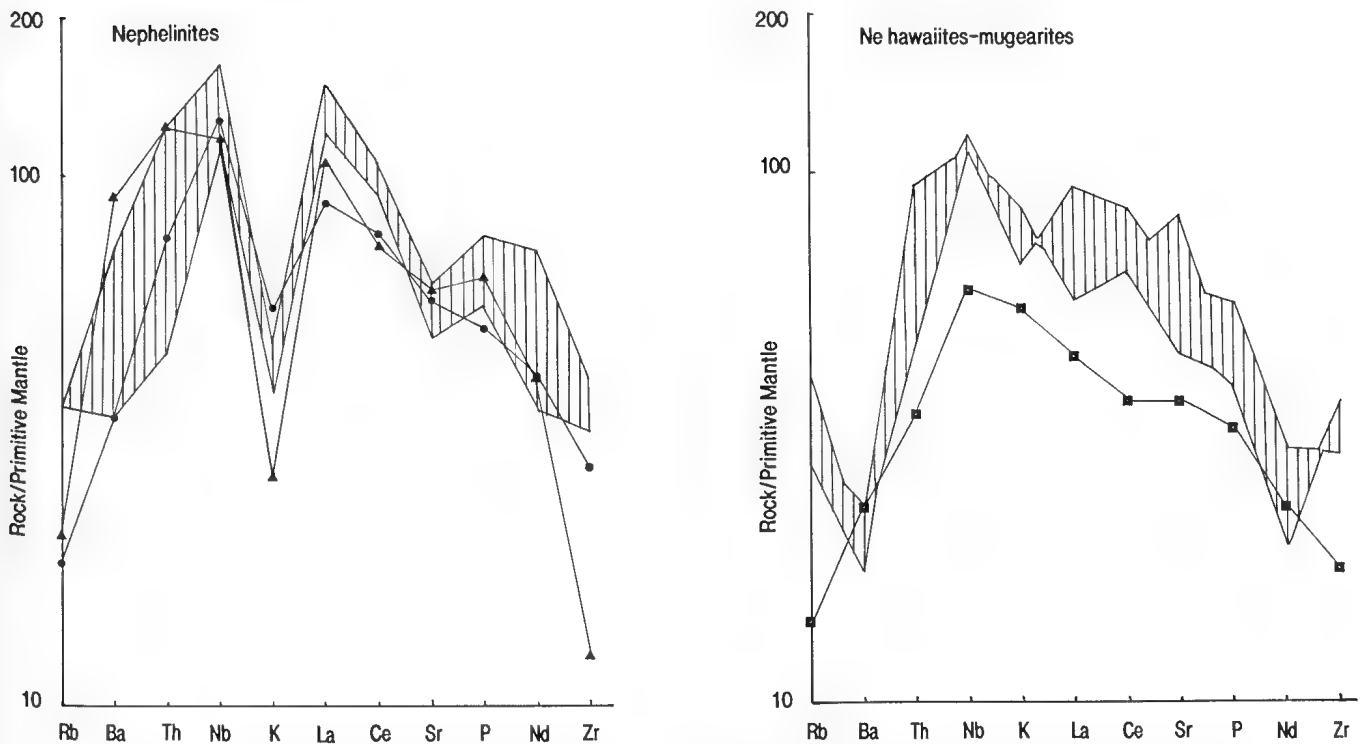


Fig. 9. Comparative incompatible minor and trace element patterns envelopes (filled sections) for Cassidys Creek-Table Cape rocks, with nephelinites (left) and ne hawaiiites-mugearites (right). Elemental abundances are normalised to primitive mantle values after Sun & McDonough (1989). Cassidys Creek nephelinites are contrasted with low Rb nephelinites from NE Tasmania (joined solid dots, data from Frey *et al.*, 1978) and Barrington volcanic province, New South Wales (joined triangles, data from O'Reilly & Zhang, 1995). Cassidys Creek evolved rocks are contrasted with low Rb nepheline hawaiite from Table Cape (joined squares, data from Table 11). The Ba enriched Cassidys Creek ne mugearite (Analyses 8–9) are not plotted due to restricted incompatible element data.

rocks in Tasmania were investigated geochemically and experimentally (Brey & Green, 1977; Frey *et al.*, 1978; Adam, 1990). The earlier work favoured low degrees of partial melting (4–7%) of garnet lherzolite mantle at 1150–1250°C and 27–30 kb, with melilitic magmas generated under high  $\text{CO}_2/\text{H}_2\text{O}$  ratios. Up to 14 wt% volatiles were needed to achieve equilibrium with a garnet lherzolite source. Later experimental work (Adam, 1990) suggests that such magmas can form under lower volatile contents (<7 wt%), with pressures controlling the magma types rather than  $\text{CO}_2/\text{H}_2\text{O}$  ratios. Thus, the Cassidys Creek melilitic nephelinite could indicate deeper source levels than for the nephelinite, without invoking significant  $\text{H}_2\text{O}/\text{CO}_2$  variability in the sources.

The relatively high  $\text{TiO}_2/\text{Y}$  (970–1105) and  $\text{Zr}/\text{Y}$  (10.5–11.5) key ratios for the nephelinites indicate some garnet remained in the source after melting, while  $\text{CaO}/\text{Na}_2\text{O}$  ratios (3.1–3.8) suggest significant diopside/jadeite melting or suppression of diopside activity through Ca-carbonate ion bonding (Frey *et al.*, 1978).

**Metasomatised sources for nephelinites.** The high  $\text{P}_2\text{O}_5$ , LREE and Nb in the nephelinites are compatible with 4–8% partial melting of an enriched garnet lherzolite source (Brown & McClenaghan, 1982). This, combined with the high Sr, Ba, Rb, Th, La, Ce and

Nd, suggests melting of non-refractory phases, such as amphibole, mica and apatite (O'Reilly & Griffin, 1984; O'Reilly *et al.*, 1991). Wall rock reactions between melts and metasomatised mantle above the source may also alter final trace element contents, but imprints of the main source contributions probably survive (O'Reilly *et al.*, 1991). Metasomatic amphibole and mica also increases Ti and Fe relative to Mg (Wilkinson & LeMaitre, 1987). Greater contribution of such metasomatised phases in the melilitic nephelinite source can account for its higher Ti/Mg and Fe/Mg relative to the olivine nephelinite. Low degree melting produced in equilibrium with such Fe enriched sources would also crystallise less magnesian olivines on the liquidus, as suggested by comparative phenocryst compositions in the melilitic nephelinite ( $\text{Fo}_{84}$ ) and nephelinite ( $\text{Fo}_{88}$ ). The Na/K ratios (0.74–0.78) of the nephelinites suggest amphibole dominated over mica in their contributions to the melt.

**Crystallisation within nephelinites.** Low pressure crystallisation trends in the nephelinite melts after eruption are given by changes in mineral compositions phases in phenocrysts, groundmass grain and mariolitic infillings (Tables 4, 7 and Figs 11, 12). Olivine becomes less magnesian ( $\text{Fo}_{84-88}$  to  $\text{Fo}_{72}$ ). Early pyroxenes show complex compositions, due to Al, Ti and Na substitutions



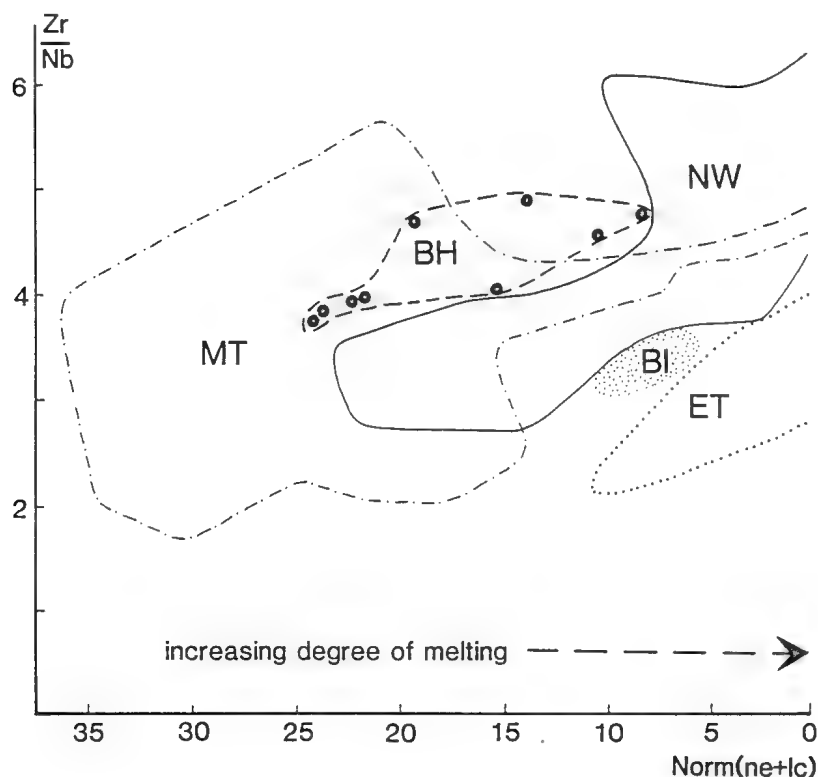


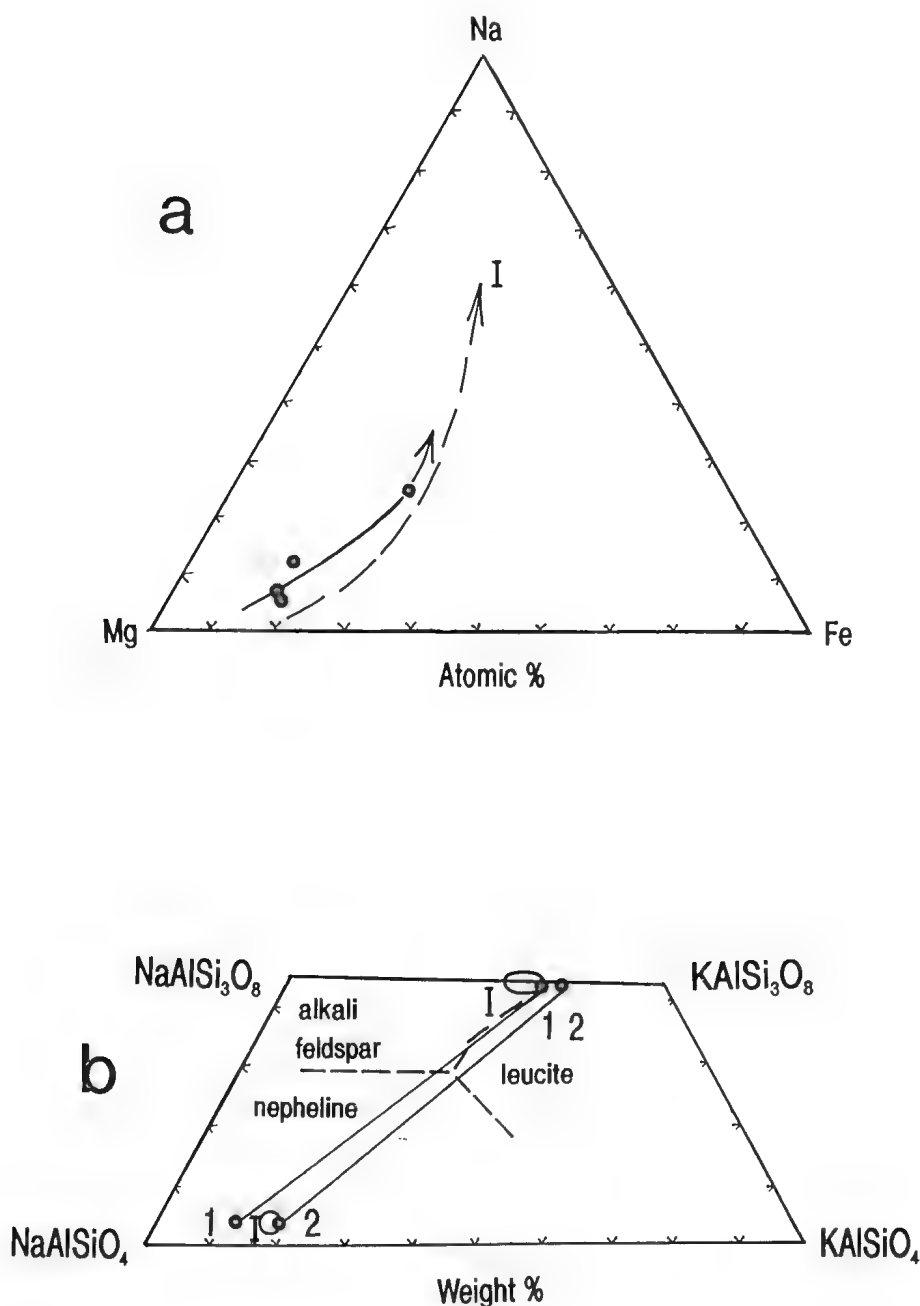
Fig. 10. Boat Harbour Zr/Nb ratios (solid dots) plotted against normative ne + lc. BH Boat Harbour alkaline field (dashed lines), MT Mid-Tasmanian alkaline field, (dot-dashed lines), NW North West Tasmanian alkali basalt field (solid line), ET East Tasmania alkali basalt field (dotted line). BI, Balleny Islands (Sabrina Island) field (stippled area). Data from this paper; Frey *et al.* (1978); Everard (1984, 1989); Sutherland (1989a,b); Sutherland *et al.* (1989); Green (1992) and F.L. Sutherland, unpublished.

in the structure ( $Wo_{39}$   $En_{35-36}$   $Fs_{0-1}$   $Cfs_{9-10}$   $Cta_{4-5}$   $Jad_{11-12}$ ), but late pyroxenes become poorer in Ca and Mg components and richer in Na and Fe end members ( $Wo_{35}$   $En_{29-30}$   $Fs_{5-6}$   $Jad_{2-3}$   $Acm_{27}$ ). Nepheline becomes more potassian ( $Ne_{84}$   $Ks_{19}$   $Q_6$  to  $Ne_{79}$   $Ks_{17}$   $Q_4$ ) and alkali feldspar more potassian and barian ( $Ab_{66}$   $Or_{27}$   $An_{57}$  to  $Ab_{24}$   $Or_{71}$   $Cn_5$ ). These trends (Fig. 11) resemble those for low pressure fractional crystallisation of nephelinites towards malignitic compositions (Wilkinson, 1977). Hydrous and halogen-bearing minerals (amphibole, mica, sodalite) and carbonates and zeolites appear in late crystallisation and indicate an alkaline volatile-rich end-stage.

Ba increases in the late alkali feldspars, consistent with crystallisation at lower temperatures and pressures (Guo & Green, 1989) and the Ba/K and Al/Si ratios in the alkali feldspars suggest crystallisation under 950°C. The co-existing sanidine and anorthoclase compositions in the late segregations suggest final crystallisation below 825°C (Seck, 1971; Fig. 3).

**Origin of the evolved members.** No primary parental basanites or basalts for evolving nepheline hawaiites and mugearites (Mg# 0.56–0.62) were identified in the sequence. The nepheline hawaiite with lowest  $SiO_2$  (43wt%) still shows a relatively reduced Mg# (0.58) compared to a primary parent.

Potential fractionation steps for the evolved rocks were evaluated using the MAGFRAC program (Morris, 1984). This matches compositions of less evolved and more evolved members of a rock series using constituent minerals in the more evolved rock. Proportions of fractionating phases are calculated and the feasibility of the process is tested by a least squares residual method. No satisfactory solutions were found for deriving any member from less evolved compositions (including the Table Cape nepheline hawaiite). Contamination of compositions through incorporation of xenoliths (lherzolite, quartzite) and secondary mineral fillings may be involved, but was minimised in the analysed pieces and cannot explain high residuals in some elements. In addition, the rocks lack the high  $SiO_2$ , low Nb/Y and negative Nb anomalies found in strong crustal contamination (Campbell & Griffiths, 1992). The main problems lie in high Na, K, Ti, Fe and Al residuals left after attempted fractionation. These remained even after adding a sodian anorthoclase megacryst composition and using a theoretical ilmenite composition instead of the observed ulvospinel. This either indicates fractionation of different phases at depth (e.g., amphibole and mica) now unrepresented in the lavas except as minor late-stage phases, or evolution of members from varied batches of parental magmas. The first option is not

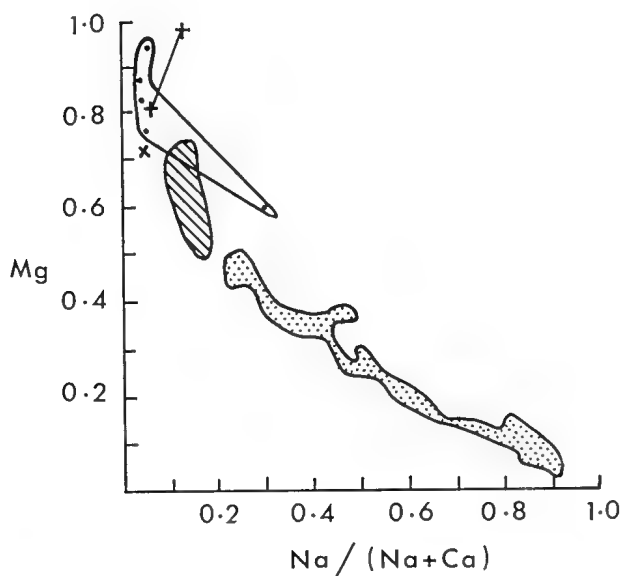


**Fig. 11.** Comparative pyroxene, nepheline and alkali feldspar compositions from Cassidys Creek and Inverell olivine nephelinite and associated late mariolitic segregations. **a.** Mg-Fe-Na diagram showing Cassidys Creek plots (dots) and trend (solid arrow) compared to Inverell trend (I, dashed arrow, from Wilkinson, 1977). **b.** Undersaturated quadrilateral residua system for nepheline and alkali feldspars showing plots (dots) of Cassidys Creek co-existing nepheline and alkali feldspar (joined by tie lines), with 1 olivine nephelinite groundmass, 2 late segregation. Comparative Inverell, NSW, compositions are shown by enclosed circles (1) and the nepheline-alkali feldspar-leucite boundary curves at  $P \text{ H}_2\text{O} = 1000$  bars are designated by heavy dashed boundaries, after Wilkinson (1977).

readily testable, but fractionation involving Ti amphibole to reduce Na, Ti and Fe (Green *et al.*, 1974) would increase  $\text{SiO}_2$  and  $\text{K}_2\text{O}$  over the typical Cassidys Creek values. Similarly Ti-mica fractionation would exacerbate  $\text{SiO}_2$  and  $\text{K}_2\text{O}$  mismatches. The presence of high pressure cumulate wehrlite in a mantle-derived nepheline mugearite favours fractionation

of melts through crystallisation of phases observed as phenocrysts in these rocks.

A potential parental trend can be estimated from an evolved composition (Analysis 5, Table 11) through addition of the wehrlite phases (Table 9), in their approximate modal proportions ( $\text{Cpx}_5 \text{ Spl}_3 \text{ Ol}_2$ ). Even if the cumulate is not directly related to the host, its



**Fig. 12.** Mg and Na/Na+Ca plots for Cassidys Creek late-stage pyroxenes, compared to evolved pyroxenes values from Tenerife Canary Island magma chamber (Wolff, 1987). Dots enclosed in open field: Cassidys Creek olivine nephelinite. Inclined cross: Cassidys Creek nepheline hawaiiite. Tied crosses: Cassidys Creek melt reaction vein in lherzolite. Hatched field: Tenerife phonolites. Stippled field: Tenerife sodalite-nepheline syenites.

presence indicates potential for such fractionation. A 10% addition of wehrlite mineralogy produces a near primitive nepheline hawaiiite magma (Mg# 0.66, an/an+ab 44%, ne 19%). A 15% addition produces a primary basanite magma (Mg# 0.68, an/an+ab 52%, ne 19%). More primitive compositions are achieved by adding observed megacryst olivine (Mg<sub>90</sub>), as an early liquidus phase. The estimated primary basanite remains strongly sodic (Na<sub>2</sub>O/Na<sub>2</sub>O+K<sub>2</sub>O 0.74) in this fractionation scheme. Such a primitive basanite (ne hawaiiite) from Oatlands, Tasmania (Mg# 0.68, an/an+ab 46%, ne 16%) was investigated experimentally by Adam (1990). The near-liquidus phase relationships were consistent with melting of garnet lherzolite mantle at 26kb and 1200°C for a magma containing 2wt% CO<sub>2</sub> and 4.5wt% H<sub>2</sub>O.

**Further evolution.** The anorthosites with quartz nuclei suggest some high-level feldspar crystallisation within the evolved lavas. However, lack of feldspar phenocrysts in the rocks and the negative correlations achieved in using anorthoclase megacrysts compositions in the MAGFRAC calculations for evolving these rocks limits feldspar controls. This is reinforced by positive Ba and Ca correlations, which are incompatible with plagioclase control, and by enrichment in Ba over Rb in the highest Ba-value evolved rocks, which does not accord with alkali feldspar control.

The anorthoclase megacrysts may represent more felsic magma at depth, being more sodian than anorthoclase crystallising in the hosts (Ab<sub>81</sub> Or<sub>15</sub> An<sub>4</sub> cf Ab<sub>75</sub> Or<sub>21</sub> An<sub>4</sub>). The negligible Ba (<0.2wt% BaO)

in the megacryst anorthoclase is consistent with crystallisation at higher temperatures or pressures relative to late anorthoclase-sanidine crystallisation in the lavas, which took place below 825°C (Seck, 1971; Fig. 3). In considering Ba partitioning in anorthoclase megacrysts in basalts, Guo *et al.* (1992) favoured their growth from melts of benmoreite compositions. These points and lack of alkali feldspar fractionation in trace element patterns of Cassidys Creek evolved lavas, suggests megacryst anorthoclase crystallised from a sodic benmoreite melt formed separately to the surface lavas. If the accompanying zircon megacrysts were also derived from these melts, then absence of Eu depletion in the zircon rare earth patterns further indicates they are not fractionated from the surface magmas.

Pyroxenes in late segregations, cavities and reaction veins in lherzolite xenoliths (Fig. 12) are compared with those evolving in highly differentiated undersaturated alkaline magma chambers (Tenerife, Canary Islands; Wolff, 1987). The high Mg and low Na/Na+Ca of Cassidys Creek pyroxenes suggest limited evolution. This probably also applies to underlying magmatic processes, as pyroxene phenocrysts in Cassidys Creek lavas are not significantly different in Mg/Na+Ca ratios to the late pyroxenes.

### Cassidys Creek/Tasmanian Comparisons

Relationships of the Cassidys Creek sequence to other Tasmanian Tertiary volcanic rocks are compared in Figs 4, 5, 8 and 10.

**Alkaline relationships.** The Cassidys Creek sodic sequence differs from most Tasmanian alkaline lineages, that include K-rich rocks (Sutherland *et al.*, 1989), in its consistent sodic signature (Table 11). The more evolved rocks are the most soda-rich recorded in Tasmania. This sodic character extends to the prominent sodian anorthoclase megacrysts, that elsewhere are relatively rare in Tasmanian basalts. It may represent a local source signature, as it does not extend beyond Table Cape. There, basalt pyroclastics contain K-rich olivine nephelinite, although the succeeding nepheline hawaiiite flow has similar Na/K ratio to Cassidys Creek rocks. Despite its distinctive Na/K ratios the Cassidys Creek sequence generally falls within Tasmanian lineages for such rocks (Fig. 4).

The Cassidys Creek nephelinites differ from some Tasmanian nephelinites (e.g., Scottsdale) in their incompatible element patterns, particularly in their relative K/Rb (Fig. 9).

**Zirconium relationships.** Cassidys Creek and Table Cape evolved rocks differ from most Tasmanian evolved sequences in showing negative to only minor positive correlations of Zr with increasing D.I. and Mg# (Fig. 8). The most evolved Cassidys Creek rocks are poorer in Zr (up to 430 ppm) than are similarly evolved rocks elsewhere in Tasmania (up to 660 ppm). Zircon megacrysts found in these relatively low Zr evolved

rocks are not readily equated with such Zr levels, as the magmas are insufficiently evolved to fractionate zircon to initiate such Zr depletions and the zircon REE lack typical fractionation patterns. The low Zr in these zircon-bearing rocks indicates little significant contamination has resulted through zircon resorption.

The Zr/Nb ratios of Cassidy's Creek rocks (3.7–5.0) in relation to increasing feldspathoidal (ne +lc) content shows a restricted trend relative to the mid-Tasmanian alkaline association (Fig. 10). Their field extends away from the alkaline associations and falls outside the alkali basalt-tholeiitic basalt association in NW Tasmania. It is well removed from east Tasmanian alkali basaltic fields. This separate Zr/Nb trend for the evolved Cassidy's Creek rocks reflects their unusual Zr content relative to similar Tasmanian rocks, with Zr and Nb reaching comparable levels in both primary and evolved rocks (Fig. 9).

**Isotopic relationships.** Limited strontium, neodymium and lead isotopic data on Cassidy's Creek melilite nephelinite and Table Cape nepheline hawaiiite (Ewart *et al.*, 1988) shows low radiogenic  $^{87}\text{Sr}/^{86}\text{Sr}$  values (0.70294–0.70309 $\pm$ 4) and relatively high  $^{143}\text{Nd}/^{144}\text{Nd}$  (0.51292 $\pm$ 13) and  $^{206}\text{Pb}/^{204}\text{Pb}$  (19.141–19.656). Such isotopic values typify Tasmanian alkaline rocks and differ from most east Australian values (McDonough *et al.*, 1985; Ewart & Menzies, 1989). They reflect a HIMU (high U/Pb) mantle component mixed with a Mid-Ocean Ridge Basalt (MORB) component (Ewart *et al.*, 1988; Sun *et al.*, 1989; Lanyon *et al.*, 1993).

The Cassidy's Creek nephelinites differ from some low  $^{87}\text{Sr}/^{86}\text{Sr}$  Tasmanian nephelinites (Scottsdale) that show low Rb, Ba and K relative to the standard St Helena HIMU component (Sun *et al.*, 1989). These low Scottsdale values may reflect residual phlogopite left in the source. As the Scottsdale nephelinite is transitionally K-rich, retention of phlogopite in Cassidy's Creek sources is minimal judging from the higher Ba and Rb in the Cassidy's Creek nephelinites.

### Discussion

The main features of the Cassidy's Creek sequence are:

- 1 consistent sodic character, including the anorthoclase megacrysts,
- 2 co-existing melilite nephelinite and nephelinite,
- 3 unusual Zr/zircon relationships in evolved basalts,
- 4 HIMU isotopic signatures.

**Sodic character.** This probably marks dominant entry of amphibole over mica into the melts from the source rocks, although the role of residual phlogopite needs consideration. Experimental work on amphibole and phlogopite metasomatised peridotite showed that nephelinitic and basanitic melts can vary in Na/K contents when generated at around 28kb, depending on

the precise temperature regime (Mengel & Green, 1989). At 1195°C melts have Na<sub>2</sub>O/K<sub>2</sub>O ratios under 1 and at 1250°C Na/K = 1, ratios less than expected for melts saturated with phlogopite. Thus, amphibole breakdown was a key process in forming these melts, while phlogopite only made a subordinate contribution and could remain in the source. However, those melts leaving residual phlogopite should show K<sub>2</sub>O of 1.6wt% or more. This is not reached in the Cassidy's Creek nephelinites or in the calculated primary basanite parent for the evolved basalts. In contrast, the Scottsdale nephelinite contains close to 1.6wt% K<sub>2</sub>O (Frey *et al.*, 1978).

All this suggests Cassidy's Creek magmas came from amphibole enriched mantle sources, in which subordinate phlogopite became consumed during melting. Hydroxy amphibole is normally stable up to 28kb and amphibole and phlogopite occur together under water saturated conditions between 25–28kb (Mengel & Green, 1989). This is the pressure range suggested for Tasmanian sodic basanite from Oatlands (Adam, 1990). However, if the melilite-nephelinite magma was generated at deeper levels than the nephelinite magmas under reduced volatile contents, then amphiboles entering melilite-nephelinite melts formed at pressures over 28kb would be F- and K-bearing amphiboles as the stable members (Foley, 1991).

**Melilite-nephelinite/nephelinite relationships.** The trace element patterns show the melilite nephelinite is relatively enriched in many incompatible elements including light rare earths. Its lower Fo phenocryst olivine composition also suggests a melt derived from a less magnesian-rich source. This indicates a greater metasomatised source input within the melilite-nephelinite melt than in the nephelinite melts.

The nephelinite pattern is closer to that predicted for an enriched amphibole-apatite metasomatised peridotite source (O'Reilly & Zhang, 1995), as described from Barrington, NSW, nephelinites (Fig. 9). This suggests greater amphibole incorporation into Cassidy's Creek nephelinite than into the melilite nephelinite. However, less extreme depletion in Rb and K indicates more phlogopite entered the Cassidy's Creek nephelinite than in the more extreme amphibole dominated Barrington nephelinites.

The fairly low and similar H<sub>2</sub>O and CO<sub>2</sub> contents of both Cassidy's Creek melilite nephelinite and nephelinite (around 1.4wt% total volatiles) suggest these melts were both derived from sources with modest rather than extreme volatile contents. Adam's (1990) model of differential depths of origin from sources under 7wt% volatiles is favoured, rather than melt production from sources varying in volatiles up to 14wt%. In the latter case, high H<sub>2</sub>O and CO<sub>2</sub> might be expected as found in some melilite nephelinites (e.g., H<sub>2</sub>O 4.5wt%, CO<sub>2</sub> 2.9wt%; Herchenberg volcano, East Eiffel; Bednarz & Schmincke, 1990). However, one problem here is the quick loss of such volatiles during Herchenberg eruptions to give CO<sub>2</sub>, H<sub>2</sub>O poor members, so that the original source character can be lost.

**Zirconium/zircon relationships.** The low Zr relative to Mg# in the evolved magmas is a puzzling feature. One explanation is a restricted fractionation process in these magmas, such as previously proposed for some Tasmanian alkaline lavas (Wilkinson, 1977) and for feldspathoidal mugearites in the New England basalt field (Wilkinson & Hensel, 1991). This implies derivation of magmas from a metasomatised peridotite mantle source, giving less mafic and higher Fe/Mg primary magmas as starting points for further fractionation. It could explain the difficulty in deriving these evolved magmas by conventional fractionation processes, as utilised in the MAGFRAC program. Although a primary basanite can be modelled by adding wehrlite mineralogy from cumulates in a nepheline mugearite, these cumulates are rare at Cassidys Creek and may only represent a minor fractionation process.

A scheme that requires a highly metasomatised, amphibole-dominated mantle source to produce more "evolved" sodic primary melts is feasible given the sodic "amphibole metasomatised" nature of the sources suggested by the high Na/K and Zr in the older nephelinites. The high Zr found in the nephelinites could even come from the sodic amphiboles, as such amphiboles are capable of accommodating over 4wt%  $\text{ZrO}_2$  (Pearce, 1989). Small volume "evolved" felsic melts forming at depth would also be rich in Na and Zr and could crystallise the anorthoclase and zircon found as megacrysts in later more voluminous "evolved" lavas. Such coarse intrusive veins would not record fractionation processes, which would explain lack of Eu depletion in the zircon megacrysts.

Preliminary uranium-lead isotope dating of Cassidys Creek zircon megacrysts give U-Pb ages between  $20.6 \pm 4.8$  and  $12.8 \pm 4.6$  Ma with the most accurate age at  $15.3 \pm 1.7$  Ma (F.L. Sutherland & P.D. Kinny, unpublished data). This places zircon formation at an early stage of Cassidys Creek "evolved" magmatism ( $14.2 \pm 0.1$ – $13.9 \pm 0.7$  Ma; Tables 1 & 2), compatible with early melting in the source region.

**HIMU relationships.** The Cassidys Creek sequence includes the typical HIMU isotopic source signature of Tasmanian alkaline volcanic rocks. This HIMU signature is also found in plume related basalts formed off the Tasmanian east coast and in the Balleny Islands (Ross Sea) as part of the Balleny plume system (Green, 1992; Lanyon *et al.*, 1993; Sutherland, 1994). The plume signature, besides its HIMU isotopic character, shows trace element ratios that include low La/Nb and low large ion lithophile element/Nb ratios. This plume signature appears in some east Tasmanian basalts with ages related to migratory lithospheric passage past the Balleny plume system which is now sited near Antarctica. The question arises whether the Cassidys Creek sequence shows any influence of this Tasman (Balleny) plume line and represents magmatism related to its peripheral path.

Key incompatible element ratios for Cassidys Creek rocks, eastern Tasmanian basalts (both earlier and similar ages to Cassidys Creek lavas), Balleny plume

basalts and HIMU oceanic islands are compared in Table 13. The older east Tasmanian basalts fall in the Balleny plume range, but the younger east Tasmanian and Cassidys Creek lavas fall outside the range. However, all these Tasmanian basalts lie within the HIMU oceanic island range.

Thus, although sharing HIMU characteristics, not all Tasmanian alkaline basalts share the Balleny plume imprint. This is in keeping with eruption of the Cassidys Creek sequence (26–9 Ma), when Tasmania had largely migrated past the Tasman (Balleny) plume line and was entering into the domain of the separate Coral Sea-Cato Trough-North Tasmania plume system (Sutherland 1991, 1994, 1996). The precise relationships of these plume systems to the Tasmanian basalts remain for further study. However, many of the east Australian lava fields are now related to Oceanic Island Basalt (OIB) sources (O'Reilly & Zhang, 1995) and zircon megacryst generation appears to reflect plume migrations (Sutherland, 1996).

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## Appendix

**Table 1.** K-Ar Age Determinations, Cassidys Creek Volcanic Rocks. \* Denotes radiogenic  $^{40}\text{Ar}$ . Whole rock ages in Ma with error limits  $\pm$  I.S.D. Constants used  $^{40}\text{K} = 0.01167$  atom %,  $\lambda\beta = 4.962 \times 10^{-10}\text{y}^{-1}$ ,  $\lambda\epsilon = 0.581 \times 10^{-10}\text{y}^{-1}$ . Age determinations by A. Webb, Amdel Report G7800/89.

Sample	%K	$^{40}\text{Ar}^*(\times 10^{-11})$ moles/g)	$^{40}\text{Ar}^*/$ $^{40}\text{Ar}$ total	Age
Olivine nephelinite	1.14	5.2319	0.885	26.4 $\pm$ 0.2
(mariolitic host)	1.13			
Olivine melilite nephelinite	1.125	5.1690	0.927	26.3 $\pm$ 0.3
(from Sutherland & Wellman, 1986)	1.124			
Nepheline mugearite	2.09	5.1541	0.896	14.2 $\pm$ 0.1
(Irbys Road flow)	2.07			

**Table 2.** Fission track age determinations, Cassidys Creek zircons. Coloured Group (4 grains) and Pale Group (6 grains) Standard (RHO D) and induced (RHO I) track densities measured on mica external detectors ( $g = 0.5$ ), and fossil track densities on internal mineral surfaces. Total tracks counted over both groups were RHO D (2699), RHO S (1059) and RHO I (2433). Ages were calculated using  $\tau = 87.7$  for dosimeter glass U3 (Green, 1985). Determinations by P.F. Green, Geotrack International, Geology Department, University of Melbourne (Report No.65 held in the Australian Museum).

Sample No.	Colour Group & Range	RHO D $\times 10^6\text{cm}^{-2}$	RHO S $\times 10^6\text{cm}^{-2}$	RHO I $\times 10^6\text{cm}^{-2}$	U ppm av(range)	Age (Ma)
8722-34	Pink-orange-red	0.632	2.453	4.737	348(193-441)	13.9 $\pm$ 0.7
	Pale	0.632	0.599	1.689	134 (30-281)	9.5 $\pm$ 0.6

**Table 3.** Representative mineral analyses, olivine melilite nephelinite. Cationic formulae are based on 6 oxygens (pyroxenes), 14 oxygens (melilite), 32 oxygens (nepheline and spinel) and 26 oxygens (sodalite and apatite). Analyses based on determinations from A. Ewart, University of Queensland, using electron microprobe facilities in the Geology Department, University of Melbourne.

Analysis	Diopside		Melilite		Nepheline	Magnetite	Sodalite	Fluor
wt%	(core)	(rim)	(core)	(rim)	(K-rich)	ulvospinel	(Cl-rich)	-apatite
SiO <sub>2</sub>	48.98	51.51	42.94	43.19	42.98	0.14	39.68	0.76
TiO <sub>2</sub>	2.62	1.41	0.15	0.05		21.00	0.08	
Al <sub>2</sub> O <sub>3</sub>	3.72	1.01	6.81	6.64	32.68	0.54	30.66	
Cr <sub>2</sub> O <sub>3</sub>	0.15	0.06	0.06			0.59		
"FeO"	5.83	5.30	4.19	4.06	0.96	69.95	1.04	0.31
MnO	0.13	0.17	0.06			0.88		
MgO	13.84	14.84	7.16	7.52		2.96		
CaO	24.43	24.49	33.45	34.31	0.11	0.07	0.12	54.39
Na <sub>2</sub> O	0.46	0.57	4.33	4.07	15.70	0.11	20.89	
K <sub>2</sub> O			0.05	0.09	6.87	0.01	0.19	
P <sub>2</sub> O <sub>5</sub>								39.46
Cl,F							Cl 7.82	F 3.26
							0=Cl1.76	0=F 1.37
Total	100.16	99.36	99.20	99.93	99.30	96.25	98.72	96.81
Si <sup>4+</sup>	1.827	1.926	3.942	3.938	4.188	0.024	6.381	0.133
Ti <sup>4+</sup>	0.073	0.040	0.010	0.004		2.596	0.010	
Al <sup>3+</sup>	0.164	0.045	0.736	0.714	3.752	0.104	5.811	
Cr <sup>3+</sup>	0.004	0.002	0.004			0.076		
Fe <sup>2+</sup>	0.182	0.166	0.322	0.310	0.080	9.612	0.140	0.045
Mn <sup>2+</sup>	0.004	0.005	0.004			0.124		
Mg <sup>2+</sup>	0.769	0.827	0.980	1.022		0.724		
Ca <sup>2+</sup>	0.976	0.981	3.290	3.352	0.012	0.012	0.023	10.188
Na <sup>1+</sup>	0.033	0.041	0.770	0.720	2.964	0.036	6.513	
K <sup>1+</sup>			0.006	0.010	0.852	0.004	0.039	P5.840
							Cl 2.131	F 1.802
Σ cations	4.032	4.033	10.064	10.070	11.848	13.312	21.046	18.008
	Wo 49.5	Wo 49.2	Ca 80.9	Ca 82.1	Ne 78.5	Usp 59.5	Na 75.0	Ca 57.1
	En 42.9	En 42.5	Na 18.9	Na 17.6	Ks 16.9	Mt 20.8	K 0.4	P 32.8
	Fs 7.6	Fs 8.3	K 0.2	K 0.3	Q 4.6	Mf 17.6	Cl 24.6	F 10.1
						Hc 1.2		
						Cm 0.9		

**Table 4.** Representative mineral analyses, olivine nephelinite. Cationic formulae are based on 4 oxygens (olivine), 6 oxygens (pyroxenes), 32 oxygens (nepheline and feldspar) and 24 oxygens (amphiboles and micas). Analysed totals are normalised for anhydrous phases for closer comparison with totals for hydrous phases. Analysts D.F. Hendry and B.J. Barron. \* May represent the presence of BaO.

Analysis wt%	Olivine (large) (small)		Diopside (large) (small)		Nepheline (grdmass)	Anorthoclase (grdmass)	Ti-mica (grdmass)	Amphibole (grdmass)
SiO <sub>2</sub>	40.37	38.52	47.71	49.70	44.50	65.41	37.67	46.74
TiO <sub>2</sub>	0.04		2.50	2.85		0.31*	8.71	1.23
Al <sub>2</sub> O <sub>3</sub>	0.14		4.81	3.76	33.09	20.62	11.81	9.13
Cr <sub>2</sub> O <sub>3</sub>			0.35					
"FeO"	11.55	20.91	5.96	6.34	0.82	0.31	10.14	7.63
MnO	0.21	0.39	0.09	0.14				0.17
MgO	47.50	39.83	13.20	13.76			15.70	16.41
CaO	0.09	0.35	23.76	22.61	0.59	1.49	1.46	13.45
Na <sub>2</sub> O	0.05		1.61	0.90	16.92	7.33	0.40	1.79
K <sub>2</sub> O	0.04		0.01		4.08	4.53	7.72	0.29
Total	99.99	100.00	100.00	100.00	100.00	100.00	93.61	96.84
Si <sup>4+</sup>	0.998	0.997	1.791	1.849	8.484	11.656	6.105	7.060
Ti <sup>4+</sup>	0.001		0.071	0.080			1.061	0.140
Al <sup>3+</sup>	0.004		0.213	0.165	7.440	4.332	2.258	1.624
Cr <sup>3+</sup>			0.011					
Fe <sup>2+</sup>	0.239	0.453	0.187	0.197	0.132	0.044	1.374	0.964
Mn <sup>2+</sup>	0.004	0.008	0.003	0.005				0.020
Mg <sup>2+</sup>	1.749	1.536	0.738	0.760			3.791	3.692
Ca <sup>2+</sup>	0.003	0.010	0.955	0.902		0.284	0.253	2.176
Na <sup>1+</sup>	0.003		0.117	0.065	6.252	2.532	0.126	0.524
K <sup>1+</sup>	0.001		0.001		0.992	1.028	1.597	0.056
Σ cations	3.002	3.003	4.087	4.023	23.420	19.876	16.565	16.256
	Fo 87.9	Fo 77.1	Wo 49.3	Wo 47.8	Ne 83.8	Ab 65.9	Mg 60.9	Mg 54.0
	Fa 12.1	Fa 22.9	En 50.1	En 44.6	Ks 9.4	Or 26.7	Fe 22.1	Fe 14.1
			Fs 0.6	Fs 7.6	Q 5.5	An 7.4	Ti 17.0	Ca 31.9

**Table 5.** Representative mineral analyses, nepheline mugearite. Cationic formulae based on 4 oxygens (olivine), 6 oxygens (pyroxenes), 32 oxygens (feldspar and zeolite). Analyses B.J. Barron. \* May represent presence of BaO.

Analysis	Olivine		Diopside		Anorthoclase		Sanidine	Zeolite
wt%	(phenocryst)	(grdmass)	(core)	(rim)	(grdmass)	(vein)	(grdmass)	(vein)
SiO <sub>2</sub>	39.37	35.95	51.05	48.31	63.53	64.49	65.38	48.50
TiO <sub>2</sub>	0.09		1.04	1.72	0.12*	0.23*	0.11*	0.05*
Al <sub>2</sub> O <sub>3</sub>	0.24	0.12	2.38	4.69	22.21	20.69	19.08	23.96
Cr <sub>2</sub> O <sub>3</sub>		0.01	0.10	0.22				
“FeO”	16.97	31.65	6.30	7.72	0.26	0.32	0.56	0.71
MnO	0.21	0.69	0.15	0.12		0.04	0.02	
MgO	42.90	31.16	14.71	12.95	0.02	0.13	0.07	3.00
CaO	0.20	0.33	23.66	23.50	3.26	2.25	0.12	7.21
Na <sub>2</sub> O		0.03	0.56	0.77	7.82	7.96	6.07	0.28
K <sub>2</sub> O	0.03	0.08	0.05	0.01	2.78	3.88	8.58	1.11
Total	100.01	100.01	100.00	100.01	100.00	99.99	99.99	84.30
Si <sup>4+</sup>	0.998	0.985	1.900	1.817	11.321	11.529	11.838	10.130
Ti <sup>4+</sup>	0.001		0.029	0.049	0.016	0.030	0.015	0.008
Al <sup>3+</sup>	0.007	0.004	0.104	0.208	4.663	4.359	4.070	5.897
Cr <sup>3+</sup>		0.002	0.003	0.007				0.005
Fe <sup>2+</sup>	0.360	0.725	0.196	0.243	0.040	0.047	0.086	0.123
Mn <sup>2+</sup>	0.004	0.016	0.005	0.004		0.006	0.004	
Mg <sup>2+</sup>	1.620	1.271	0.816	0.725	0.005	0.037	0.019	0.932
Ca <sup>2+</sup>	0.005	0.010	0.943	0.947	0.621	0.432	0.024	1.613
Na <sup>1+</sup>		0.002	0.040	0.056	2.700	2.758	2.131	0.113
K <sup>1+</sup>	0.001	0.003	0.002	0.000	0.630	0.083	1.981	0.295
cations	2.996	3.018	4.038	4.053	19.996	20.081	20.168	19.116
	Fo 81.8	Fo 63.7	Wo 46.6	Wo 44.0	Ab 68.3	Ab 67.7	Ab 51.5	Ca 79.8
	Fa 18.2	Fa 36.4	En 47.0	En 50.3	Or 15.9	Or 21.7	Or 47.9	K 14.6
			Fs 6.5	Fs 5.7	An 15.7	An 10.6	An 0.6	Na 5.6

**Table 6.** Representative phenocryst, groundmass and megacryst phases, zircon-bearing evolved lavas. Analyses normalised to 100%. Cationic formulae based on 4 oxygens (olivine), 6 oxygens (pyroxene), 32 oxygens (feldspar). Analyses D.F. Hendry and B.J. Barron. \* May represent presence of BaO.

Rock Mineral wt%	Nepheline hawaiiite (Analysis 7)				Anorthoclase		Nepheline mugearite (Analysis 8)			
	Olivine core	(rim)	Clinopyroxene core	(rim)	grd-mass	mega-cryst	Ol pheno-cryst	Cpx pheno-cryst	Anorthoclase grd-mass	mega-cryst
SiO <sub>2</sub>	39.96	(39.17)	50.39	(51.74)	59.42	67.29	40.08	45.67	61.48	67.42
TiO <sub>2</sub>			1.79	(1.31)			0.02	3.45	0.15*	
Al <sub>2</sub> O <sub>3</sub>			3.40	(2.55)	23.99	19.89		5.95	23.36	20.01
Cr <sub>2</sub> O <sub>3</sub>				(0.32)		0.03	0.12			
"FeO"	15.17	(17.46)	8.63	(7.01)	0.91	0.14	12.72	9.29	1.25	0.13
MnO	0.17	(0.19)	0.14			0.24	0.15			
MgO	44.20	(42.75)	13.42	(14.41)			46.88	11.80	0.39	
CaO	0.21	(0.23)	21.63	(22.17)	0.97	0.73	0.02	22.80	2.85	0.69
Na <sub>2</sub> O			0.58	(0.48)	10.25	9.57		0.76	7.13	9.17
K <sub>2</sub> O	0.07				4.45	2.40		0.01	3.58	2.58
NiO	0.26	(0.20)								
Si <sup>4+</sup>	1.050	(0.996)	1.883	(1.917)	10.812	11.864	0.996	1.737	11.039	12.001
Ti <sup>4+</sup>			0.050	(0.036)			0.000	0.099	0.016	
Al <sup>3+</sup>			0.150	(0.112)	4.136		0.267	4.943	4.198	
Cr <sup>3+</sup>				(0.009)		0.001	0.004			
Fe <sup>2+</sup>	0.318	(0.371)	0.270	(0.217)	0.136	0.024	0.264	0.295	0.188	
Mn <sup>2+</sup>	0.004	(0.004)	0.004		0.001	0.005				
Mg <sup>2+</sup>	1.657	(1.621)	0.747	(0.796)		1.736	0.668	0.103		
Ca <sup>2+</sup>	0.006	(0.006)	0.866	(0.880)	0.188	0.136	0.001	0.928	0.549	0.133
Na <sup>1+</sup>			0.042	(0.035)	3.616	3.272		0.056	2.481	3.164
K <sup>1+</sup>	0.002				1.032	0.540		0.000	0.774	0.586
Ni <sup>2+</sup>	0.006	(0.004)								
cations	3.043	(3.002)	4.012	(4.002)	20.932	19.954	2.999	4.059	20.093	20.082
	Fo 83.8	(81.3)	Wo 43.9	(43.9)	Ab 74.7	Ab 82.7	Fo 86.8	Wo 45.3	Ab 65.2	Ab 81.5
	Fa 16.2	(18.7)	En 42.8	(44.5)	Or 21.4	Or 13.7	Fa 13.2	En 43.6	Or 20.3	Or 15.1
			Fs 13.3	(11.7)	An 3.9	An 3.4		Fs 11.1	An 14.4	An 3.4

Analysis wt%	Olivine	Augite	Na-augite	Sanidine	Nepheline	Sodalite	Ulvospinel	Amphibole	Ti-Mica
SiO <sub>2</sub>	38.56	54.00	53.17	62.80	43.46	39.32	1.06	52.63	37.47
TiO <sub>2</sub>		0.37	1.34		0.10		13.58	2.74	10.70
Al <sub>2</sub> O <sub>3</sub>		0.79	0.60	18.73	33.30	30.06	0.23	2.60	12.08
Cr <sub>2</sub> O <sub>3</sub>	0.40	0.10							
"FeO"	24.75	6.48	12.10	1.02	0.94	1.30	78.48	8.21	11.53
MnO	0.66	0.14	0.28		0.08		1.14	0.19	0.10
MgO	35.77	15.81	10.60		0.07		1.53	17.40	15.03
CaO	0.22	21.63	17.61		0.15			7.08	
Na <sub>2</sub> O		0.65	4.21	2.59	15.32	22.36		5.59	0.17
K <sub>2</sub> O		0.03	0.03	11.92	6.58	0.14		1.82	8.27
Cl						7.33			
BaO				2.94		O=Cl1.76			
Total	100.00	100.00	100.01	100.00	100.00	98.86	96.02	98.26	95.35
Si <sup>4+</sup>	1.020	1.990	2.010	11.764	8.360	6.356	0.366	7.836	6.010
Ti <sup>4+</sup>		0.010	0.040		0.020		3.540	0.303	1.290
Al <sup>3+</sup>		0.030	0.030	4.134	7.550	5.727	0.094	0.459	2.280
Cr <sup>3+</sup>		0.010							
Fe <sup>2+</sup>	0.547	0.200	0.380	0.160	0.150	0.176	22.747	1.023	1.550
Mn <sup>2+</sup>	0.013		0.010		0.010		0.334	0.021	0.010
Mg <sup>2+</sup>	1.413	0.870	0.600		0.020		0.789	3.861	3.590
Ca <sup>2+</sup>	0.007	0.850	0.710		0.030		1.127		
Na <sup>+</sup>		0.050	0.310	0.941	5.710	7.008	1.617	0.310	0.050
K <sup>1+</sup>			0.000	2.849	1.610	0.029		0.344	1.690
Cl						2.008			
Ba <sup>2+</sup>				0.215					
Σ cations	3.000	4.010	4.090	20.064	23.460	21.303	27.870	16.591	16.480
	Fo 72.0	Wo 43.4	Wo 47.6	Ab 23.5	Ne 76.3	Na 77.5	Mt 48.9	Mg 64.2	K 55.8
	Fa 28.0	En 46.9	En 43.4	Or 71.1	Ks 19.4	K 0.3	Usp 42.1	Fe 17.0	Mg 24.1
		Fs 9.7	Fs 9.0	Cn 5.4	Q 4.3	Cl 22.2	Mf 8.5	Ca 18.8	Ti 20.1
							Hc 0.5		

**Table 8.** Representative analyses, spinel lherzolite xenoliths and reaction replacements, olivine nephelinite host. Cationic formulae are based on 4 oxygens (olivine), 6 oxygens (pyroxenes), 32 oxygens (spinel, feldspar). Analyses D.F. Hendry. CIPW norms for glasses are calculated on a volatile content basis, assuming volatiles by difference from 100% totals.

Mineral wt%	Spinel lherzolite xenolith				Reaction phases in xenolith				
	Olivine	Diopside	Enstatite	Cr-spinel	Olivine	Augite	Sanidine	Glass 1	Glass 2
SiO <sub>2</sub>	40.75	53.02	56.30	1.14	40.50	56.40	67.53	46.84	45.67
TiO <sub>2</sub>		0.29	0.14	0.26					0.15
Al <sub>2</sub> O <sub>3</sub>		4.76	3.16	47.23		0.37	17.66	10.78	13.49
Cr <sub>2</sub> O <sub>3</sub>		0.87	0.41	20.75		1.76			
"FeO"	9.98	2.56	6.06	9.90	10.23	3.52	1.21	2.60	5.68
MnO	0.11		0.16	0.23	0.17	0.12			
MgO	49.71	15.71	31.75	19.82	48.91	18.23	0.32	12.61	14.12
CaO		21.64	0.94	0.17	0.15	18.06		1.71	2.20
Na <sub>2</sub> O		0.90				1.40	5.64	0.72	
K <sub>2</sub> O						0.17	7.76	5.05	2.59
NiO	0.32				0.18				
Total	100.87	99.75	98.91	99.50	100.13	100.03	100.13	80.31	83.92
Si <sup>4+</sup>	0.992	1.922	1.970	0.245	0.994	2.032	12.128	Or 30	Q 7
Ti <sup>4+</sup>		0.008	0.010	0.041				Ab 6	Or 15
Al <sup>3+</sup>		0.203	0.130	11.959		0.016	3.740	An 8	An 11
Cr <sup>3+</sup>		0.250		3.522		0.050		C 1	C 7
Fe <sup>2+</sup>	0.203	0.078	0.180	1.777	0.210	0.106	0.180	Hy 32	Hy 43
Mn <sup>2+</sup>	0.002			0.042		0.004	0.004	Ol 2	Mt 1
Mg <sup>2+</sup>	1.804	0.849	1.650	6.345	1.790	0.979	0.088	Mt 1	Il 0
Ca <sup>2+</sup>		0.840	0.040	0.040	0.004	0.697			
Na <sup>1+</sup>		0.063				0.098	1.960		
K <sup>1+</sup>						0.008	1.776		
Ni <sup>2+</sup>	0.006				0.003				
Σ cations	3.008	3.988	3.980	23.972	3.006	3.988	19.872	100.0	100.0
	Fo 89.9	Wo 37.7	En 88.6	Sp 79.6	Fo 89.4	Wo 33.9	Ab 52.5	Na 14.4	Na 0
	Fa 10.1	En 57.1	Fs 9.5	Cm 16.6	Fs 10.6	En 61.4	Or 47.5	K 66.7	K 58
		Fs 5.2	Wo 1.9	Usp 3.8		Fs 4.7	An 0.0	Ca 18.9	Ca 42



**Table 9.** Comparative olivine, pyroxene and spinel compositions, cumulate inclusions and host lherzolite-bearing nepheline mugearite. Analyses recalculated to 100% totals, with cationic formulae based on 4 oxygens (olivine), 6 oxygens (pyroxenes) and 32 oxygens (spinel). Analyses B.J. Barron.

Mineral wt%	Spinel wehrlite			Nepheline mugearite			Megacrysts	
	Ol	Cpx	Spl	Ol	Cpx	Spl	Ol	Opx
SiO <sub>2</sub>	40.24	49.92	0.12	39.39	51.04	0.17	41.05	54.72
TiO <sub>2</sub>	0.01	1.37	0.39	0.09	1.04	26.01	0.04	
Al <sub>2</sub> O <sub>3</sub>	0.12	8.30	63.60	0.24	2.38	0.42	0.01	5.10
Cr <sub>2</sub> O <sub>3</sub>	0.01	0.13	0.28		0.10	0.06		0.39
"FeO"	14.10	4.20	14.42	16.98	6.30	49.33	9.19	6.29
MnO	0.10	0.16	0.01	0.21	0.15	0.85	0.12	0.13
MgO	45.25	14.40	21.12	42.91	14.71	2.39	49.47	32.34
CaO	0.14	19.71	0.06	0.20	23.66	0.75	0.09	0.96
Na <sub>2</sub> O		1.75			0.56	0.01		0.05
K <sub>2</sub> O	0.03	0.06			0.05	0.02	0.03	0.04
Si <sup>4+</sup>	1.005	1.819	0.025	0.998	1.900	0.052	1.003	1.892
Ti <sup>4+</sup>		0.036	0.060	0.002	0.029	6.055	0.001	
Al <sup>3+</sup>	0.003	0.357	15.259	0.067	0.104	0.149	0.003	0.208
Cr <sup>3+</sup>		0.004	0.044		0.003	0.015		0.011
Fe <sup>2+</sup>	0.294	0.128	2.454	0.359	0.196	17.952	0.188	0.182
Mn <sup>2+</sup>	0.002	0.005	0.002	0.004	0.005	0.219	0.003	0.004
Mg <sup>2+</sup>	1.683	0.782	6.405	1.620	0.816	1.104	1.800	1.665
Ca <sup>2+</sup>	0.004	0.769	0.013	0.005	0.943	0.246	0.002	0.036
Na <sup>1+</sup>		0.123			0.040	0.005		0.004
K <sup>1+</sup>		0.003		0.001	0.002	0.007	0.001	0.002
Σ cations	2.991	4.026	24.262	3.055	4.038	25.803	3.001	4.004
	Fo 85.1	Wo 36.1	Sp 79.4	Fo 81.8	Wo 46.6	Usp 71.1	Fo 90.6	En 88.5
	Fa 14.9	En 59.9	Hc 14.9	Fa 18.2	En 47.0	Mf 15.9	Fa 9.4	Fs 9.5
		Fs 4.0	Mt 4.4		Fs 6.5	Mt 12.0		Wo 2.0
			Cm 0.3			Hc 0.9		

**Table 10.** Representative Analyses, Crustal Inclusions. Cationic formulae are based on 6 oxygens (pyroxenes) and 32 oxygens (feldspars). Analyses D.F. Hendry and B.J. Barron.

Mineral wt%	Two-Pyroxene Granulite			Anorthosite
	Enstatite	Diopside	Andesine	Oligoclase
SiO <sub>2</sub>	53.94	53.11	58.00	62.25
TiO <sub>2</sub>	0.12	0.29		
Al <sub>2</sub> O <sub>3</sub>	1.53	2.79	26.32	24.00
Cr <sub>2</sub> O <sub>3</sub>	0.16	0.25		
"FeO"	17.32	6.41		0.14
MnO	0.29			
MgO	25.75	14.20		
CaO	0.29	21.78	7.86	5.21
Na <sub>2</sub> O		0.92	6.61	8.16
K <sub>2</sub> O			0.33	0.62
Total	99.40	99.75	99.12	100.33
Si <sup>4+</sup>	1.969	1.959	10.452	11.012
Ti <sup>4+</sup>	0.003	0.008		
Al <sup>3+</sup>	0.066	0.121	5.592	4.996
Cr <sup>3+</sup>	0.005	0.007		
Fe <sup>2+</sup>	0.529	0.198		0.020
Mn <sup>2+</sup>	0.009			
Mg <sup>2+</sup>	1.401	0.780		
Ca <sup>2+</sup>	0.011	0.861	1.520	
Na <sup>1+</sup>		0.066	2.308	2.800
K <sup>1+</sup>			0.076	0.140
Σ cations	3.993	4.000	19.944	19.956
	En 72.2	Wo 42.0	Ab 59.1	Ab 71.3
	Fs 27.2	En 46.5	An 38.9	An 25.1
	Wo 0.6	Fs 11.6	Or 1.9	Or 3.6

Table 11A. Chemical Analyses, Cassidys Creek and Table Cape Basalt Suites.

Major Elements	1	2	3	4	5	6	7	8	9
SiO <sub>2</sub>	38.77	40.49	42.51	44.46	46.63	47.37	47.15	47.00	47.26
TiO <sub>2</sub>	3.34	2.81	2.26	2.00	1.62	1.82	1.73	1.71	1.81
Al <sub>2</sub> O <sub>3</sub>	8.75	8.92	12.61	13.25	13.77	14.62	13.85	14.12	14.39
Fe <sub>2</sub> O <sub>3</sub>	5.22	6.42	7.07	4.41	3.92	5.02	3.18	3.77	3.56
FeO	7.87	6.62	6.61	9.34	7.25	6.12	7.76	7.93	7.71
MnO	0.21	0.19	0.19	0.18	0.18	0.18	0.17	0.23	0.20
MgO	12.56	13.75	8.92	9.63	8.56	6.70	7.04	7.98	7.09
CaO	14.72	12.42	8.81	8.47	7.44	7.36	8.04	7.22	7.19
Na <sub>2</sub> O	3.89	3.94	4.42	3.85	5.98	4.61	5.07	6.48	6.00
K <sub>2</sub> O	1.34	1.10	1.87	1.53	2.12	2.16	2.37	2.14	2.44
P <sub>2</sub> O <sub>5</sub>	1.56	1.21	1.20	0.70	0.84	0.88	0.86	0.81	0.84
H <sub>2</sub> O	1.18	1.29	2.75	2.14	2.08	2.86	2.62	1.20	1.60
CO <sub>2</sub>	0.24	0.18	0.35		0.10	0.16	0.12		
Total	99.65	99.34	99.57	99.35	100.49	99.86	99.96	100.59	100.09
C.I.P.W. norm									
Or			11.41	9.30	12.73	13.16	14.39	12.73	14.64
Ab			10.57	14.96	15.69	25.25	18.81	15.20	17.06
An	2.49	3.47	9.34	14.77	4.54	13.22	8.25	3.14	5.20
Lc	6.31	5.20							
Ne	18.11	18.42	15.20	10.05	19.35	8.11	13.69	21.66	18.68
Di	30.49	37.48	20.79	19.78	21.79	14.32	21.43	22.55	20.84
Ol	21.93	22.38	21.15	22.33	17.82	17.13	15.02	16.73	15.35
Mt	3.21	3.21	3.41	3.24	2.74	2.78	2.72	2.84	2.77
Il	6.44	5.44	4.43	3.91	3.13	3.56	3.38	3.27	3.49
Ap	3.75	2.92	2.94	1.71	2.02	2.15	2.09	1.93	2.02
Cc	0.55	0.42	0.82	—	0.23	0.38	0.28	—	—
Cs	6.79	1.11	—	—	—	—	—	—	—
D.I.	24.4	23.6	37.2	34.3	47.8	46.5	46.9	49.6	50.4
An%	100.0	100.0	46.9	49.7	22.4	34.4	30.5	17.1	23.4
Mg value	0.673	0.693	0.582	0.612	0.621	0.563	0.579	0.594	0.574
Na <sub>2</sub> O/Na <sub>2</sub> O+K <sub>2</sub> O	0.74	0.78	0.70	0.72	0.74	0.68	0.68	0.75	0.71
Na <sub>2</sub> O+K <sub>2</sub> O/Al <sub>2</sub> O <sub>3</sub>	0.60	0.57	0.50	0.41	0.59	0.46	0.53	0.61	0.59
ASI(Al <sub>2</sub> O <sub>3</sub> /CaO+Na <sub>2</sub> O+K <sub>2</sub> O)	0.44	0.51	0.83	0.96	0.89	1.03	0.89	0.89	0.92

Table 11B. Trace elements.

ppm	1	2	3	4	5	6	7	8	9
Ni	246	390	230	278	240	165	155	210	160
Cr	548	650	320	325	320	220	220		
Co		63	53		46	47	43		
Sc		25	12	16	15	11	13		
V	238	240	165	165	125	145	140		
Ba	516	250	165	165	125	145	140	200	210
Zr	452	370	330	201	410	410	410	390	430
Y	43	32	23	19	22	22	22	24	22
Sr	1296	1050	1350	794	1000	1750	960	970	1150
Rb	23	24	20	9	18	19	27	17	17
Nb	120	96	82	44	87	86	83		
La	105	84	65	31	45	47	39		
Ce	192	165	150	66	120	120	115		
Nd	98	50	41	32	29	30	27		
Zn	127	135	175		160		150	165	155
Cu	85	96	125		62	63	56	43	34
Sn		<4	13		7	6	5		
W		70	115		54	72	36		
Bi		6	5		5	<5	<5		
Mo		5	10		6	8	8		
As		29	20		22	20	24		
Th	11	<4	4	3	7	<4	8		
U	<2	<5	5	<1	<5	<5	<5		
Pb	20	5	9		5	<4	<4		
Ga	22	15	25		27	26	26		
Zr/Nb	3.77	3.85	4.02	4.57	4.71	4.77	4.94		
Sr/Rb	56.3	43.8	67.5	88.2	55.6	92.1	35.5	47.1	67.6
Ba/Rb	22.4	10.4	8.3	18.3	6.9	7.6	5.2	11.8	12.4
Sr/Ba	2.5	4.2	8.2	4.8	8.0	12.1	6.9	4.9	5.5
Rb/Nb	0.19	0.25	0.24	0.20	0.21	0.22	0.33		

1. Olivine melilite nephelinite (block), north Cassidys Creek (8235E, 6690N).
2. Olivine nephelinite (block), north Cassidys Creek (8235E, 6685N).
3. Nepheline hawaiite, north Cassidys Creek (8240E, 6690N).
4. Nepheline hawaiite, (flow base), south Table Cape (9316E, 6506N).
5. Anorthoclase-nepheline mugearite (flow), north Cassidys Creek (8236E, 6685N).
6. Nepheline hawaiite (block), north Cassidys Creek (8235E, 6690N).
7. Anorthoclase-nepheline hawaiite (block), north Cassidys Creek (8235E, 6690N).
8. Anorthoclase-nepheline mugearite (block), north Cassidys Creek (8235E, 6690N).
9. Anorthoclase-nepheline mugearite (flow), north Cassidys Creek (8245E, 6680N).

Analysis 1. School of Earth Sciences, Macquarie University, Sydney (J. Bedford).

Analyses 2–3, 5–9. Tasmanian Department of Mines (Nos. 872732–972737, 850242–850243).

Analysis 4. Geology Department, University of Queensland (A. Ewart).

Table 12. Petrographic details, basalt types, Cassidys Creek.

Rock Type	Texture	Phenocrysts	Groundmass
Olivine-melilite nephelinite (Analysis 1)	microporphyritic, rock includes mantle debris	olivine ( $Mg_{84}$ ), melilite ( $Ca_{71-72} Mg_{21} Fe_{6-7}$ )	zoned Al-Ti diopside ( $Ca_{50} Mg_{42} Fe_8$ ), melilite ( $Ca_{71} Mg_{22} Fe_7$ ), nepheline ( $Na_{78} K_{22}$ ), interstitial sodalite ( $Na_{75} K_{0-1} Cl_{24-25}$ ), ulvospinel
Olivine-nephelinite (Analysis 2)	glomeroporphyritic, rock includes mantle debris	olivine ( $Mg_{89-92}$ ) diopside ( $Mg_{39} Ca_{50} Fe_{10}$ ), rims ( $Mg_{37} Ca_{51} Fe_{12}$ )	olivine, clinopyroxene, ulvospinel, nepheline, zoned alkali feldspar. Segregations of nepheline ( $Na_{84-88} K_{10-14} Ca_{1-2}$ ), anorthoclase ( $Na_{56-66} K_{26-27} Ca_{7-5}$ )
	mariolitic cavity, prismatic crystals up to 4.5 mm projecting inwards from margins towards an irregular central cavity	diopside ( $Mg_{44-46} Ca_{44-47} Fe_{9-11}$ ) in radiating prisms zoned to sodian augite ( $Mg_{35-38} Ca_{42-45} Fe_{20-30}$ ) and partly altered to Ti richterite ( $Mg_{64-71} Ca_{16-19} Fe_{12-17}$ ), subhedral nepheline ( $Na_{77-81} K_{19-22} Ca_{0-1}$ ), zoned sanidine ( $K_{74-80} Na_{20-26}$ ) tablets, radiating groups and intergrowths including Ba sanidine ( $K_{71} Na_{24} B_5$ ), sodalite ( $Na_{78} Cl_{22}$ ) overgrown on pyroxenes and containing aegirine augite (?), accessory ulvospinel ( $Fe_{79-85} Ti_{12-17} Mg_{2-5}$ ), Ti phlogopite ( $Mg_{55-56} Fe_{23-25} Ti_{20-25}$ ), apatite, ilmenite. Intersertal glass, radiating feldspathic mesostasis and a botryoidal carbonate filling.	
Nepheline-hawaiiite (Analysis 3)	aphyric rock, includes mantle debris		olivine, prismatic clinopyroxene, stumpy to poikilitic subhedral nepheline, zoned and simply twinned feldspar, scattered ulvospinel.
Nepheline-hawaiiite (Analyses 6 & 8)	microporphyritic, anorthoclase and zircon xenocrysts, crustal debris	zoned olivine ( $Mg_{84}$ ) with rims ( $Mg_{81-69}$ )	zoned sodic plagioclase, nepheline, alkali feldspar, scattered ulvospinel. Mariolitic cavities with prismatic diopside ( $Mg_{38} Ca_{47} Fe_{15}$ ), mosaic anorthoclase ( $Na_{74-75} K_{21-22} Ca_4$ ), minor nepheline and zeolitic amygdales.
Nepheline-Mugearite (Analysis 5)	microporphyritic, anorthoclase xenocrysts, mantle debris	zoned olivine ( $Mg_{83-71}$ ), rare zoned diopside ( $Mg_{37-42} Ca_{47-50} Fe_{10-13}$ )	olivine ( $Mg_{63}$ ), clinopyroxene needles, zoned sodic feldspar ( $Na_{63-68} K_{16-22} Ca_{10-16}$ ) interstitial sanidine ( $Na_{51-52} K_{47-48} Ca_{0-1}$ ) scattered ulvospinel ( $Fe_{74} Ti_{24} Mg_4$ ).
Nepheline mugearite (Analyses 8 & 9)	microporphyritic, anorthoclase and zircon xenocrysts, crustal debris	olivine ( $Mg_{87}$ ) Al-Ti augite ( $Mg_{35-34} Ca_{49-50} Fe_{15-16}$ )	olivine, clinopyroxene, ulvospinel, nepheline ( $Na_{90-91} K_{8-9} Ca_{0-1}$ ), poikilitic anorthoclase ( $Na_{65-66} Ca_{14-15} K_{20-21}$ ), yellow glass.

**Table 13.** Incompatible trace element ratios, Tasmanian, Balleny Plume and HIMU basalts.

Basalt Group	Zr/Nb	La/Nb	Ba/Nb	Ba/Th	Rb/Nb	K/Nb	Ba/La
Cassidys Creek nephelinites	3.7–3.9	0.88	2.6–4.3	47–63	0.19–0.25	93–95	3.0–4.9
Table Cape ne hawaiiite	4.6	0.70	2.0	55	0.20	289	5.3
NE Tasmanian nephelinite	3.3	0.64	2.6	38	0.12	133	4.0
NE Tasmanian alkali basalt	3.6	0.53	5.2	73	0.37	156	9.7
Balleny Plume basalts	3.1–4.6	0.57–0.62	5.0–7.2	64–99	0.32–0.72	111–216	9.3–12.6
HIMU oceanic islands	0.4–5.6	0.07–0.85	1.0–8.2	23–151	0.01–0.45	13–266	2.4–15.4

Cassidys Creek/Table Cape ratios from this paper. NE Tasmanian nephelinite ratios from Frey *et al.* (1978). NE Tasmanian alkali basalt ratios from Sutherland (1989b) and A.E. Ewart unpublished data. Balleny plume basalt and HIMU oceanic island basalt ratios from Lanyon *et al.* (1993).





**Hermit Crabs of the Family Parapaguridae  
(Crustacea: Decapoda: Anomura) from Australia:  
Species of *Strobopagurus* Lemaître, 1989,  
*Sympagurus* Smith, 1883 and Two New Genera**

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**ABSTRACT.** The deep-water parapagurid hermit crab fauna from Australia is much more diverse than previously believed. The most recent information on parapagurids (De Saint Laurent, 1972) indicated the presence of three species and one subspecies in this region. The study of numerous unidentified or unreported parapagurid materials deposited in various Australian museums revealed the presence of at least 21 species. With the exception of three species of the genus *Parapagurus* Smith, 1879, all other parapagurids known from Australia are discussed. The heterogeneous genus *Sympagurus* Smith, 1883, is revised and restricted. Two new genera, *Oncopagurus* and *Paragiopagurus*, are proposed for a number of species previously assigned to *Sympagurus*. Four new species were discovered and are described, *Sympagurus papposus*, *S. soela*, *S. villosus*, and *Oncopagurus cidaris*. Of the previously recognised species, those found to be poorly described in the literature are diagnosed and illustrated. The Australian material is compared with types and/or supplemental material from other regions of the Pacific deposited in major museums or institutions. The affinities and important morphological variations of the species are discussed, and the overall distributions of the species updated. The subspecies of *Sympagurus acutus* (De Saint Laurent, 1972) are elevated to specific rank, and assigned to *Paragiopagurus* n.gen. The juvenile stages of *S. brevipes* (De Saint Laurent, 1972), an abundant species that reaches a large size, is described, and compared with the adults. Keys for the identification of all parapagurid genera and Australian species (except those of *Parapagurus*), are presented. The distribution of the species is summarised.

LEMAITRE, RAFAEL, 1996. Hermit crabs of the family Parapaguridae (Crustacea: Decapoda: Anomura) from Australia: species of *Strobopagurus* Lemaître, 1989, *Sympagurus* Smith, 1883 and two new genera. Records of the Australian Museum 48(2): 163–221.

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## Introduction

The Australian Museum zoologist, Thomas Whitelegge (1900: 135), in his account of the HMCS *Thetis* Expedition off the coast of New South Wales, remarked on the limited knowledge of the deep-water fauna from that coast, and accurately predicted that once it "has been thoroughly explored, there can be no doubt that its waters will be found as richly endowed with life as in any part of the world". In that same publication he described a new hermit crab in the family Paguridae, *Sympagurus diogenes* Whitelegge, 1900, a species that eventually would prove to be the first Parapaguridae known from Australian waters. Since then, few additions have been made to the parapagurid fauna of Australia. The use of the family Parapaguridae Smith, 1882, was abandoned by A. Milne Edwards & Bouvier (1893) and most subsequent carcinologists; however, some continued to use it. Hale (1941), for example, described in the

Parapaguridae three subspecific taxa, *Sympagurus arcuatus diogenes*, *S. a. johnstoni*, and *S. a. mawsoni*, from Tasmania and Macquarie Island. When De Saint Laurent (1972) reinstated the family Parapaguridae and presented a preliminary worldwide review of all known species, she synonymised Hale's *S. a. diogenes* with *Parapagurus diogenes*, and the other two subspecies with *P. dimorphus* (Studer, 1883). In De Saint Laurent's study, only three species and one subspecies were reported from the Australian region, all of which she placed in the genus *Parapagurus* Smith, 1879, i.e. *P. dimorphus* (Studer, 1883), *P. diogenes* (Whitelegge, 1900), *P. minutus* Henderson, 1896, and *P. pilosimanus latimanus* Henderson, 1888. Although in his revisionary studies, Lemaitre (1989, 1993) did not add any parapagurids to the Australian fauna, he did elevate *P. pilosimanus latimanus* to its original specific status, retaining it in *Parapagurus* (sensu Lemaitre, 1989), and assigned the remaining three species known from Australia at the time to the genus *Sympagurus* Smith, 1883.

Until recently, the only parapagurid material available from the Australian region was restricted to that collected during earlier major, worldwide deep-sea expeditions, such as those conducted on the British *Challenger* (1872–1876), U.S. *Albatross* (late 1800's to early 1900's), Dutch Siboga Expedition (1899–1900), and Danish *Galathea* (1950–1952). During the decade of the 1980's, however, several intense, deep-water expeditions sponsored by the Australian government obtained a large number of parapagurid specimens that accumulated, unidentified, in various museums in the country. The examination of all these specimens revealed the existence of a rich parapagurid fauna on the Australian continental shelf and slope regions. Twenty-one species are represented in the materials examined. Of these, one is of *Strobopagurus* Lemaitre, 1989; 17 are assignable to *Sympagurus* Smith, 1883 (sensu Lemaitre, 1989), four of them new; and three of *Parapagurus* Smith, 1879 (sensu Lemaitre, 1989). The study of the materials clearly showed the need to reevaluate the heterogeneous assemblage of species currently assigned to *Sympagurus*, a genus previously reinstated, broadly defined, and divided into three informal groups of species (Lemaitre, 1989, 1994). As result, *Sympagurus* is herein redefined and restricted to a group of species (Group 2 of Lemaitre, 1994) typified by *Sympagurus pictus* Smith, 1883, and characterised by the presence of a vestigial pleurobranch on each side of the last thoracic somite. A new genus, *Oncopagurus*, is proposed for a group of species (Group 1 of Lemaitre, 1994) whose representatives exhibit a curved epistomial spine. The remaining species previously assigned to *Sympagurus* (Group 3 of Lemaitre, 1994), are placed in another new genus, *Paragiopagurus*; these have not been found to share any unique character.

In this study, the Australian species of *Strobopagurus*, *Sympagurus* sensu stricto, and the new genera *Oncopagurus* and *Paragiopagurus*, all of which typically live in continental shelf and slope depths (ranging from 50 to 1000 m), are discussed. Additionally, keys to all currently recognised parapagurid genera and their Australian species are presented. Excluded from this study are species of *Parapagurus* (sensu Lemaitre, 1989), which commonly occur in depths greater than 1000 m, which will be discussed separately (Lemaitre, in prep.).

Some of the species that occur in Australian waters exhibit a broad range of morphological variations. Particularly broad are the variations seen in *Sympagurus dimorphus* (Studer, 1883) and *Oncopagurus indicus* (Alcock, 1905), which can make their identification difficult. Further complicating identification is the very dissimilar morphology seen in juveniles and adults in species such as *S. dimorphus*, or *S. brevipes* (De Saint Laurent, 1972), both of which have young that reach a size as large or larger than many adults of other congeneric species. A description of the juveniles of *S. brevipes* is included here. Juveniles of *S. dimorphus* are described in Lemaitre (1989) and Lemaitre & McLaughlin (1992).

## Materials and Methods

The majority of the Australian material used for this study has come from cruises sponsored in the 1980's by government agencies such as Commonwealth Scientific Industrial Research Organization (CSIRO), Northern Territory Fisheries, Queensland Fisheries Service, and New South Wales State Fisheries. Particularly significant for its abundance and species diversity is the material obtained during the CIDARIS I expedition, and from exploratory expeditions conducted on board the ORV *Franklin*, FRV *Kapala*, and FRV *Soela*. Abundant, supplemental material of *Sympagurus dimorphus* from New Zealand was obtained primarily from expeditions by the New Zealand Oceanographic Institute vessel RV *Tangaroa*. Additional specimens used have come from cruises conducted by at least 18 other vessels that have operated in the Australian or New Zealand regions.

During the early stages of this investigation it became apparent that the examination of types and as much supplemental material as possible would be indispensable in defining several previously described but poorly understood taxa, understanding the range of morphological variations, and confirming the existence of undescribed species. Moreover, the study of the often abundant material from outside the study area has been required in order to obtain the best estimate of the distribution of the species. This material is listed under the heading "Other Material". Types, as well as supplemental material examined, were borrowed from major museums in Australia, Europe, and the USA.

Specimens have been returned to the following museums or institutions: Australian Museum, Sydney (AM); Queensland Museum, Brisbane (QM); B.P. Bishop Museum, Honolulu, Hawaii (BPBM); Natural History Museum of Los Angeles County (LACM); Musée Océanographique, Monaco (MO); Muséum national d'Histoire naturelle, Paris (MNHN); Museum of Victoria, Melbourne (NMV); National Museum of Natural History, Smithsonian Institution, Washington, D.C. (USNM); National Museum of New Zealand, Wellington (NMNZ); Northern Territories Museum, Darwin (NTM); South Australian Museum, Adelaide (SAMA); The Natural History Museum, London (formerly British Museum [Natural History]) (NHM); Western Australian Museum, Perth (WAM); Zoölogisch Museum, Amsterdam (ZMA); and Zoologisk Museum, Copenhagen (ZMK). The holotypes and paratypes of all new species described herein have been deposited in specified Australian museums. When possible, paratypes of these new species, and/or duplicate specimens of previously known species, have been deposited in the National Museum of Natural History, Smithsonian Institution.

The general terminology used in the descriptions is that of McLaughlin (1974, 1980) and Lemaitre (1989), with exception of the 4th pereopods where the terms "subchelate" and "semichelate" are used following the definitions provided by McLaughlin (1996). In the material examined, that from Australia is listed separately by State or Territory in a clockwise direction around the

country. All materials are cited from north to south. A single measurement, shield length (SL), indicative of size, is indicated in parenthesis, as measured (to the nearest 0.1 mm) from the tip of the rostrum to the midpoint of the posterior margin of the shield. Months are abbreviated by the first three letters. Other abbreviations used are: coll., collector; sta, station; Is., island; JCU, James Cook University, Townsville; NZOI, New Zealand Oceanographic Institute.

The term juvenile, used for *Sympagurus brevipes*, is applied to those specimens with incompletely developed pleopods (all with  $SL \leq 5.5$  mm). In these specimens, the 2nd to 5th pleopods are paired, asymmetrical; in males, the 1st gonopods are rudimentary. Although some presumed juveniles were found to have clearly open gonopores, it is unclear

whether they were sexually mature.

In order to observe the armature of the chelipeds in some species, the dense setae were removed by immersing the appendage for 5–10 minutes in full-strength sodium hypochlorite (commercial "Clorox"), and subsequently cleaning the surfaces with a fine brush.

De Saint Laurent (1972) listed only holotypes in her descriptions of various new taxa. Evidently, however, she used numerous other specimens as well, most of which were labelled and catalogued as paratypes in the collections of some museums (e.g. ZMA, USNM). It is unclear whether De Saint Laurent intended to designate all, or part of those specimens as paratypes. These are included under "Other material", and marked with an asterisk following the museum number or abbreviation.

## Systematic Account

### Parapaguridae Smith, 1882

#### Key to genera of the family

1. Corneae present ..... 2
- Corneae absent ..... *Typhlopagurus* De Saint Laurent, 1972
2. Rostrum short, not exceeding eye-stalks ..... 3
- Rostrum long, exceeding eye-stalks ..... *Probeebei* Boone, 1926
3. Ocular acicles present ..... 4
- Ocular acicles absent ..... *Tylaspis* Henderson, 1885
4. Posterior carapace mostly membranous; unpaired 3rd to 5th left pleopods ..... 5
- Posterior carapace calcified; paired (asymmetrical) 3rd to 5th pleopods ..... *Bivalvopagurus* Lemaitre, 1993
5. Shield about as broad as long, or slightly broader than long; rostrum bluntly triangular or broadly rounded; abdomen twisted ..... 6
- Shield distinctly longer than broad; rostrum acutely triangular; abdomen straight ..... *Tsunogaipagurus* Osawa, 1995
6. Shield distinctly broader than long; dactyls of ambulatory legs straight or nearly so; corneae strongly dilated; males with 2nd pleopod having short exopod and strongly twisted distal segment ..... *Strobopagurus* Lemaitre, 1989
- Shield about as broad as long; dactyls of ambulatory legs curved; corneae moderately or weakly dilated; males with 2nd pleopods lacking exopod and distal segment not twisted (2nd pleopods rarely absent) ..... 7

7. Vestigial pleurobranch absent on last thoracic somite ..... 8  
 — Vestigial pleurobranch present on each side of last thoracic somite ..... *Sympagurus* Smith, 1883, s.s.
8. Epistomial spine straight, or absent ..... 9  
 — Epistomial spine strongly curved upward ..... *Oncopagurus* n.gen.
9. Phyllobranchiate or intermediate gills; 4th segment of antennal peduncle armed with dorsodistal spine; length of ocular peduncles, including corneae, at least half length of shield ..... *Paragiopagurus* n.gen.  
 — Trichobranchiate gills; 4th segment of antennal peduncle unarmed; length of ocular peduncles, including corneae, less than half length of shield (except *Parapagurus bouvieri* Stebbing, 1910) ..... *Parapagurus* Smith, 1879

### *Strobopagurus* Lemaitre, 1989

*Parapagurus*.—De Saint Laurent, 1972: 101 (in part).

*Strobopagurus* Lemaitre, 1989: 35. Type species by original designation: *Sympagurus gracilipes* A. Milne Edwards, 1891: 132. Gender: masculine.

**Diagnosis.** Eleven pairs of phyllobranchiate or intermediate gills. Shield distinctly broader than long, weakly and evenly calcified. Eye-stalks stout. Corneae strongly dilated. Fourth segment of antennal peduncle unarmed. Epistomial spine absent. Right cheliped elongate, often slender; palm rounded mesially, with weakly to well delimited dorsolateral margin. Left cheliped usually weakly calcified on merus, carpus, and often proximal portion of palm. Ambulatory legs with dactyls straight or nearly so. Fourth pereopod with propodal rasp consisting of 1 row of corneous scales. Second abdominal somite with left pleuron terminating ventrally in small subtriangular lobe. Males with well developed paired 1st and 2nd gonopods; 1st gonopods each with short, broad subtriangular distal lobe; 2nd gonopods each with rudimentary exopod and strongly twisted distal segment.

**Species.** *Strobopagurus gracilipes* (A. Milne Edwards, 1891), *S. kilburni* (Kensley, 1973), and *S. sibogae* (De Saint Laurent, 1972).

### *Strobopagurus sibogae* (De Saint Laurent, 1972)

Fig. 1

*Parapagurus sibogae* De Saint Laurent, 1972: 116, figs 10, 23 (type locality: Indonesia, Siboga Exp. sta. 12).

*Strobopagurus sibogae*.—Lemaitre, 1989: 36.

**Holotype.** Female ovig. (SL 7.4 mm), Indonesia, Siboga Exp. sta. 12, 07°15'S, 115°15.6'E, 289 m, 14 Mar 1899, coll. M. Weber, ZMA De103.109.

**Australian material.** WESTERN AUSTRALIA: 1 female ovig. (SL 7.5 mm), NW of Augustus Is., 13°33.3'S, 122°54.5'E, FRV *Soela*, 396–390 m, 14 Feb 1984, WAM 1320–86. 4 males (SL 4.6–6.0 mm), 3 females (SL 4.0–4.9 mm), NW of Collier Bay, 14°16'S, 122°38.3'E, FRV *Soela*, 302 m, 14 Feb 1984, coll. S. Slack-Smith, WAM 1314–86. 2 males (SL 4.7, 6.9 mm), NW of Collier Bay, FRV *Soela*, sta. S01/84/074, 14°16.5'S, 122°34.4'E, 302 m, 14 Feb 1984, coll. S. Slack-Smith, WAM 1316–86. 1 male (SL 5.2 mm), 1 female (SL 5.8 mm), NW of Leveque, FRV *Soela*, 14°49.0'S, 121°36.1'E, 302–300 m, coll. S. Slack-Smith, 12 Feb 1986, WAM. 1 male (SL 8.6 mm), NW of Beagle Bay, FRV *Soela*, 15°13.5'S, 121°08.9'E, 352 m, 11 Feb 1984, WAM 1107–86. 2 males (SL 7.8, 8.1 mm), 1 female (SL 5.2 mm), NW of Beagle Bay, 15°20'S, 121°09.6'E, FRV *Soela*, 300–302 m, 11 Nov 1984, coll. S. Slack-Smith, WAM 1133–86. 1 female (SL 7.9 mm), WNW of Lacepede Arch, 15°40.2'S, 120°37.3'E, FRV *Soela*, 10 Feb 1984, WAM. 1 male (SL 5.6 mm), W of Lacepede Arch, 16°55.8'S, 119°53.9'E, FRV *Soela*, 426 m, 19 Feb 1984, WAM 1307–86. 1 male (SL 4.5 mm), 1 female (SL 6.2 mm), W of Lacepede Arch, FRV *Soela*, sta. S001/84/105, 16°56.9'S, 119°52.0'E., 432 m, 21 Feb 1984 WAM 1297–86. 1 female (SL 4.8 mm), W of Lacepede Arch, 16°57'S, 119°51'E, FRV *Soela*, 436 m, 22 Feb 1984, WAM 1099–86. 1 female (SL 6.7 mm), W of Broome, FRV *Soela*, sta. 01/84/122, 17°59–54'S, 118°23–29'E, 390 m, 24 Feb 1984, WAM 863–86. 1 male (SL 6.0 mm), North West Shelf, FRV *Soela*, sta. 0184/29, 18°10.15'S, 118°14.4'E, 302 m, 2 Feb 1984, coll. T. Ward, NTM Cr 007014. 1 female (SL 4.6 mm), *Courageous*, sta. 5, 18°08'S, 118°13'E, 350–354 m, 17 Aug 1985, WAM 1011–85. 1 male (SL 5.2 mm), NNE Cape Lambert, 18°32'S, 117°21'E, FRV *Soela*, 496–504 m, 8 Apr 1982, WAM 1237–86. 4 males (SL 5.0–6.5 mm), 1 female (SL 5.3 mm), FRV *Soela*, sta. NWS-7, 18°32.2'S, 117°30.9'E, 392–400 m, 25 Apr 1982, NTM Cr 010916. 2 males (SL 5.8, 6.0 mm), 1 female (SL 5.3 mm), North West Shelf, FRV *Soela*, CSIRO cruise 0184, sta. 22, 18°34.3'S, 117°30'E, 202 m, 1 Feb 1984, NTM Cr 000669. 1 male (SL 6.5 mm), Scampi, FRV *Soela*, sta. NWS-6, 18°41.6'S, 117°18.6'E, 320–360 m, 25 Apr 1983, NTM Cr 010915. 3 males (SL 5.3–6.3 mm), North West Shelf, FRV *Soela*, sta. 0184/13, 18°55.3'S, 116°09'E, 403 m, 30 Jan 1984, NTM Cr 006858. 1 male (SL 6.0 mm), FRV *Soela*, CSIRO cruise 0184, 19°15'S, 115°38'E, sta. NNS-36 T10, 404 m, 29 Jan 1984, coll. T. Ward, NTM Cr 010914. 1 male (SL 5.5 mm), North West Shelf, FRV *Soela*, cruise 0184, sta. T/8, 19°20.2'S, 115°44.1'E, 307 m, 29 Jan 1984, NTM Cr 000670.

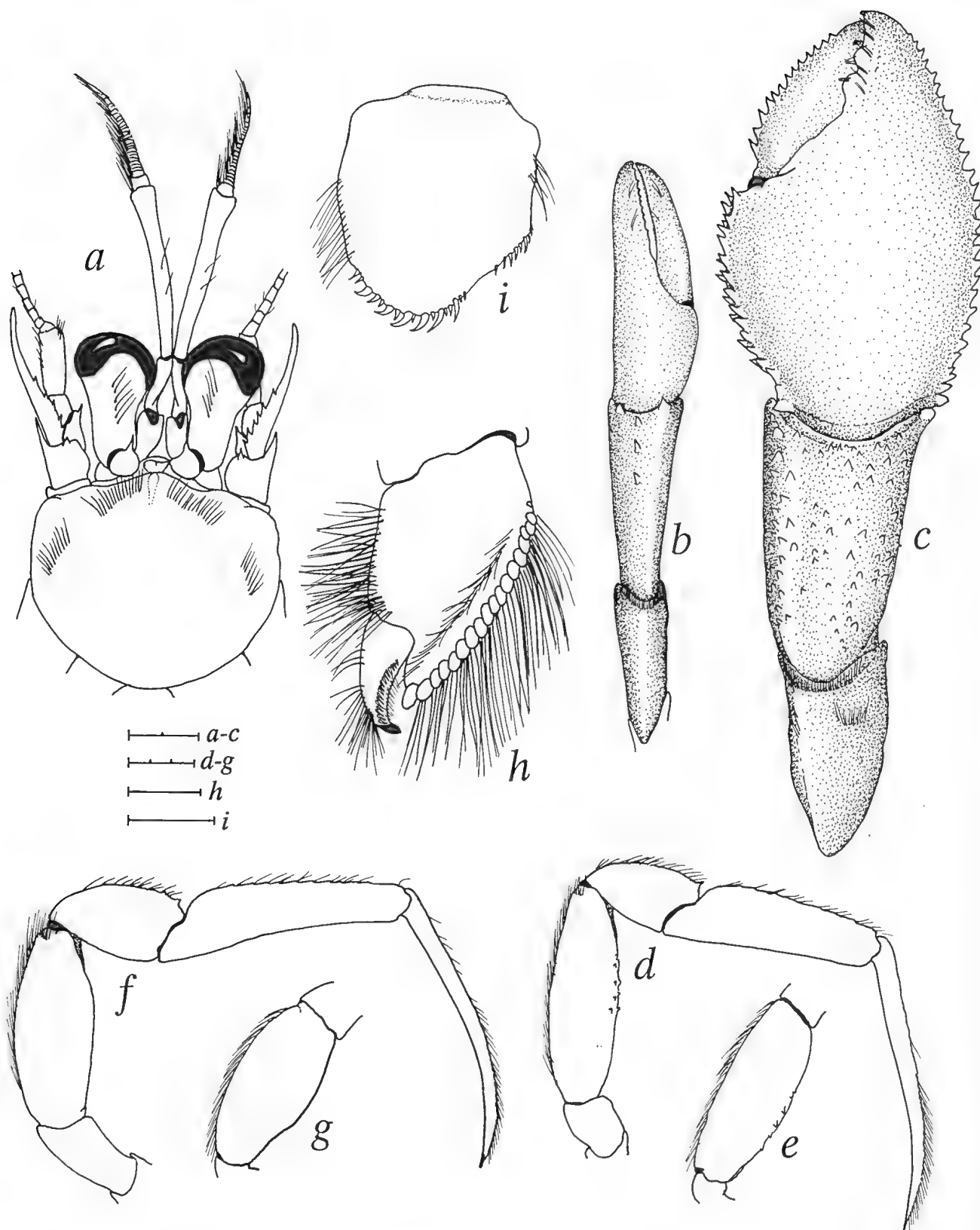


Fig. 1. *Strobopagurus sibogae* (De Saint Laurent, 1972). a, shield and cephalic appendages; b, left cheliped; c, right cheliped; d, right 2nd pereopod, lateral; e, merus of same, lateral; f, right 3rd pereopod, lateral; g, merus of same, lateral; h, propodus and dactyl of left 4th pereopod, lateral; i, telson. Scales = 2 mm (a-c), 3 mm (d-g), 0.5 mm (h), and 1 mm (i). (Male [SL 6.0 mm], Western Australia, WAM 1314-86).

QUEENSLAND: 1 male (SL 5.0 mm), Marian Plateau, FRV *Soela*, sta.0685-03, 22°34.8'S, 158°38.7'E, 314–319 m, 16 Nov 1985, NTM Cr 010917. 1 female ovig. (SL 5.8 mm), E of Gold coast, FRV *Kapala*, sta. K78-09-05, 550 m, 2 Jun 1978, AM P40419.

NEW SOUTH WALES: 1 female (SL 4.5 mm), E of Long Reef Point, Sydney, FRV *Kapala*, sta. K78-26-02, 33°43'S, 151°40'E, 143 m, 5 Dec 1978, AM P40418. 10 males (SL 2.5–6.1 mm), 6 females (SL 3.3–4.6 mm), 6 females ovig. (SL 4.5–5.5 mm), off Newcastle, NZOI *Tangaroa*, cruise U207, 34°11.1'S, 151°26'E, 198 m, 5 Oct 1982, AM P40416. 3 males (SL 5.8–7.5 mm), 1 female ovig. (SL 6.9 mm), 20 mi (37 km) off Wollongong, 238–274 m, 30 Jul 1968, AM P17613.

**Diagnosis.** Shield (Fig. 1a) convex in lateral view. Rostrum broadly rounded, with short longitudinal dorsal ridge. Ocular peduncles more than half length of shield, widening distally. Ocular acicles terminating in strong spine. Antennular peduncles exceeding distal margin of corneae by slightly more than length of ultimate segment. Antennal peduncles exceeding distal margin of corneae by about 0.3 or less length of 5th segment; 2nd segment with dorsolateral distal angle produced, terminating in strong spine (occasionally bifid), mesial margin with small spine at dorsodistal angle. Antennal acicles exceeding distal margin of corneae by as much as 0.3 length of acicle; mesial margin armed with 5 to 7 spines on proximal half. Sternite of 3rd maxilliped with small spine on each side of midline. Right chela (Fig. 1c) with dorsal surface unarmed, dactyl with row of spines on mesial margin; palm with mesial and lateral margins well delimited by row of often strong spines (usually double row on mesial margin). Ambulatory legs (Fig. 1d–g) with meri shorter on left side than on right; merus of 2nd pereopod 2.5 times as long as dorsoventral height; merus of 3rd twice as long as dorsoventral height. Fourth pereopod (Fig. 1h) with propodus elongate, length of dorsal margin subequal to greatest height; propodal rasp with 1 row of rounded scales. Anterior lobe of sternite of 3rd pereopods unarmed, setose. Uropods and telson (Fig. 1i) strongly asymmetrical; terminal margin of posterior lobes armed with strong, often curved corneous spines.

**Distribution.** Western Pacific: Indonesia, China Sea, Japan, and Australia. Depth: 40 to 550 m.

**Affinities.** This species most closely resembles *Strobopagurus gracilipes* (A. Milne Edwards, 1891); however, the two can be separated using several characters. The spines on the mesial margin of the antennal acicles and the lateral and mesial margins of the right chela are much stronger in *S. sibogae* than in *S. gracilipes*. The dorsoventral height of the meri of the 2nd and 3rd pereopods are greater in *S. sibogae* than in *S. gracilipes* (the merus length/height ratio of the 2nd and 3rd pereopods is 2.0 and 2.5 respectively in the former, and 3.0 and 3.5 respectively in the latter).

The propodus of the 4th pereopod is about as high as long in *S. sibogae*, whereas in *S. gracilipes* the propodus is distinctly higher than long (1.5 times as high as long, length measured dorsally).

### *Sympagurus* Smith, 1883, s.s.

*Sympagurus* Smith, 1883:37.—Lemaitre, 1989:36. Type species by monotypy: *Sympagurus pictus* Smith, 1883. Gender: Masculine.

*Parapagurus*.—De Saint Laurent, 1972: 101 (in part).

**Diagnosis.** Twelve pairs of gills: 11 trichobranchiate or intermediate and 1 pair of vestigial pleurobranchiae on last thoracic somite. Shield about as broad as long, or slightly broader than long; dorsal surface usually with irregularly-shaped, weakly calcified areas. Corneae weakly to moderately dilated. Fourth segment of antennal peduncle unarmed, or with small dorsodistal spine. Epistomial spine straight or absent. Right chela with rounded dorsomesial and dorsolateral margins, or sometimes operculate with well delimited dorsomesial and dorsolateral margins. Left cheliped usually well calcified. Ambulatory legs with dactyls curved. Fourth pereopod with propodal rasp consisting of 1 or more rows of corneous scales or spines. Second abdominal somite with left pleuron terminating ventrally in small subtriangular lobe. Males with moderately to well developed paired 1st and 2nd pleopods.

**Species.** In addition to the new species described herein as *S. papposus*, *S. soela*, and *S. villosus*, the following are retained in *Sympagurus* s.s.: *S. acinops* Lemaitre, 1989, *S. affinis* (Henderson, 1888), *S. andersoni* (Henderson, 1896), *S. brevipes* (De Saint Laurent, 1972), *S. dimorphus* (Studer, 1883), *S. dofleini* (Balss, 1912), *S. pictus* Smith, 1883, *S. planimanus* (De Saint Laurent, 1972), *S. poupini* Lemaitre, 1994, and *S. trispinosus* (Balss, 1911).



Key to Australian species of *Sympagurus* s.s.

(In the following key, juveniles (SL < 5.5 mm) of *S. brevipes* are not considered; *S. papposus* n.sp. is keyed twice to account for variation in the ocular acicles)

1. Propodal rasp of 4th pereopod with 1 row of scales .....2  
 — Propodal rasp of 4th pereopod with 2 or more rows of scales .....3
2. Ocular acicles simple ..... *S. planimanus*  
 — Ocular acicles multifid ..... *S. soela* n.sp.
3. Fourth antennal segment armed with dorsodistal spine ..... *S. dimorphus*  
 — Fourth antennal segment unarmed .....4
4. Ocular acicles simple or bifid (one side only) .....5  
 — Ocular acicles multifid .....6
5. Propodal rasp of 4th pereopod with 4–6 rows of scales ..... *S. brevipes*  
 — Propodal rasp of 4th pereopod with 2–3 rows scales .....7
6. Posterior lobes of telson separated by broad, shallow median cleft; merus of 3rd pereopod short, length distinctly less than 3 times dorsoventral height ..... *S. trispinosus*  
 — Posterior lobes of telson separated by narrow, deep median cleft (Fig. 10); merus of 3rd pereopod long, length 3 or more times dorsoventral height (Fig. 8i) ..... *S. papposus* n.sp.
7. Ambulatory legs with numerous long bristle-like setae dorsally on four distal segments (Fig. 15d–f); dorsal surfaces of chelae with numerous long bristle-like setae in addition to dense mat of short plumose setae (Fig. 14b,c) ..... *S. villosus* n.sp.  
 — Ambulatory legs with few scattered short setae dorsally on four distal segments (Fig. 8g–i); dorsal surfaces of chelae lacking bristle-like setae, with only dense mat of short plumose setae (Fig. 3d) ..... *S. papposus* n.sp.

*Sympagurus brevipes* (De Saint Laurent, 1972)

Figs 2, 3a,b, 4, 5a, 6

*Parapagurus arcuatus* var. *monstrosus*.—Balss, 1912: 99, pl. 10, fig. 3.

*Parapagurus brevipes* De Saint Laurent, 1972: 105, figs 2, 14 (type locality: Indonesia, Siboga Exp., sta. 12).

*Sympagurus brevipes*.—Lemaitre, 1989: 37; 1994: 412.

**Holotype.** Male (SL 12.9 mm) Indonesia, Siboga Exp., sta. 12, 07°15'S, 115°15.6'E, 289 m, coll. M. Weber, ZMA De 103.103.

**Australian material.** WESTERN AUSTRALIA: 1 female (SL

10.7 mm), NNW of Cape Leveque, FRV *Soela*, sta. 01/84/082A, 13°07.2'S, 123°15.7'E, 400 m, 15 Feb 1984, WAM 1292–86. 1 juv. sex indet. (SL 5.5 mm), NW of Augustus Is., FRV *Soela*, 13°17'S, 122°37.4'E, 494–484 m, 15 Feb 1984, USNM. 1 male (SL 10.8 mm), 1 female (SL 9.8 mm), NW of Collier Bay, FRV *Soela*, sta. 01/84/070, 13°44'S, 122°13.3'E, 496–494 m, WAM 1313–86. 1 female ovig. (SL 14.4 mm), NW of Augustus Is., FRV *Soela*, sta. S01/84/076, 13°44.5'S, 122°56.5'E, 348–350 m, 14 Feb 1984, WAM 1094–86. 1 male (SL 12.3 mm), 1 female (SL 11.7 mm), NW of Bathurst Is., FRV *Soela*, sta. S01/84/067, 14°29.4'S, 122°01.4'E, 348–350 m, 12 Feb 1984, WAM 1109–86. 1 male (SL 11.9 mm), 5 females (SL 8.5–11.1 mm), NW of Leveque, FRV *Soela*, sta. S01/84/064, 14°50.2'S, 121°31.4'E, 356 m, 12 Feb 1984, WAM 1112–86, 1312–86. 1 juv. sex indet. (SL 4.5 mm), NW of Beagle Bay, FRV *Soela*, sta. S01/84/060, 15°08.6'S, 121°03.4'E, 500–504 m, 11 Feb 1984, WAM. 3 males (SL

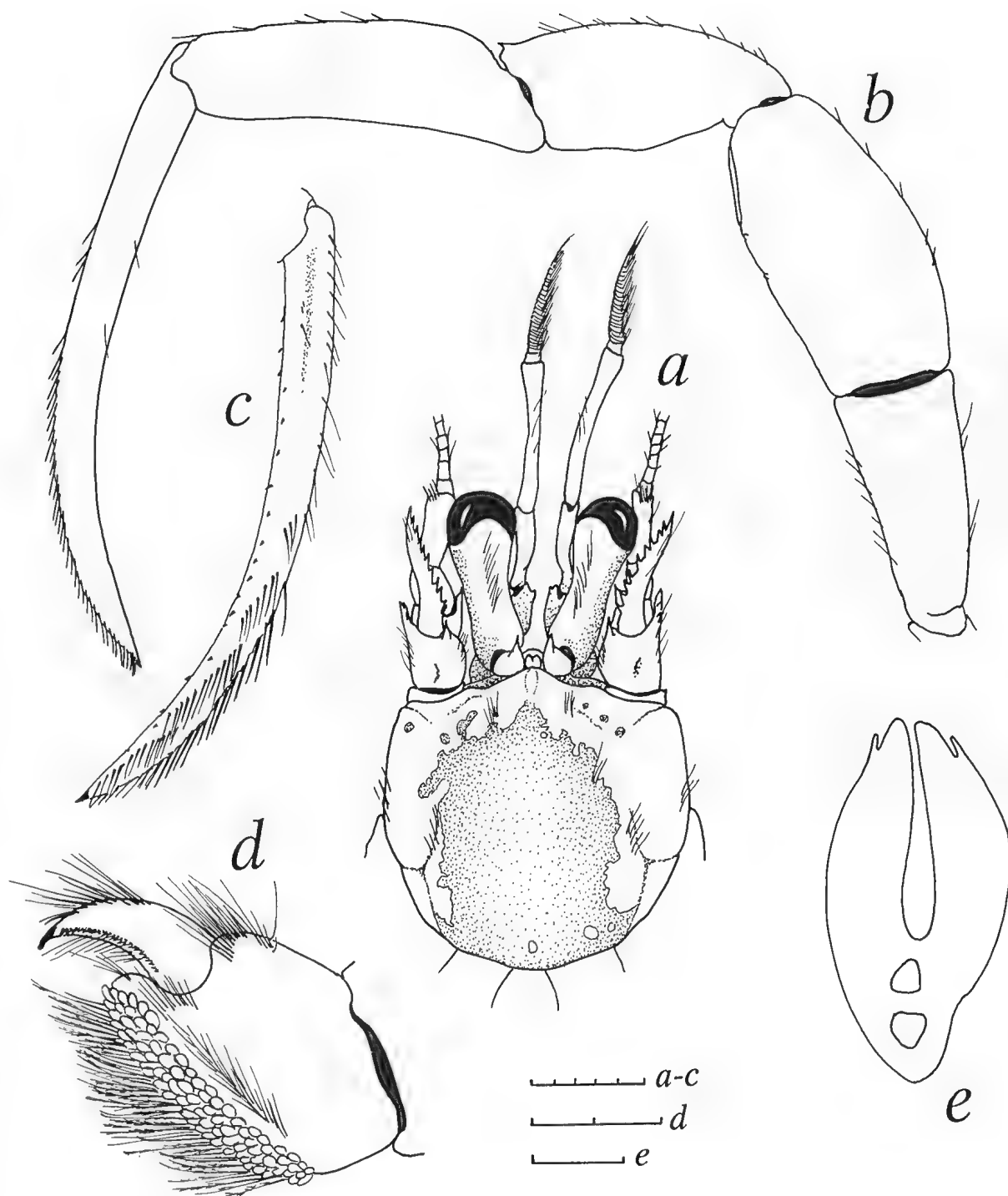


Fig. 2. *Sympagurus brevipes* (De Saint Laurent, 1972). a, shield and cephalic appendages; b, left 3rd pereopod, lateral; c, dactyl of same, mesial; d, propodus and dactyl of left 4th pereopod, lateral; e, branchia, transverse section. Scales = 5 mm (a-c), 2 mm (d), and 1 mm (e). (a, paratype female [SL 13.3 mm], Philippines, USNM 168914; b-d, holotype male [SL 12.9 mm], Indonesia, ZMA De103.103; e, paratype female [SL 14.0 mm], Philippines, USNM 168913).

8.9–12.8 mm), 1 female (SL 12.8 mm), NW of Beagle Bay, FRV *Soela*, sta. S01/84/059, 15°09.4'S, 121°05.5'E, 450–448 m, 11 Feb 1984, WAM 2022–86. 1 female (SL 7.5 mm), NW of Beagle Bay, FRV *Soela*, sta. S01/84/057, 15°13.5'S, 121°08.9'E, 352 m, 11 Feb 1984, WAM. 3 females (SL 8.1–8.3 mm), WNW of Lacepede Arch, FRV *Soela*, sta. 01/84/051, 15°40.2'S, 120°37.3'E, 500–504 m, 10 Feb 1984, USNM.

1 male (SL 9.8 mm), WNW of Lacepede Arch, FRV *Soela*, sta. 01/84/053, 15°48'S, 120°41'E, 400–396 m, 10 Feb 1984, coll. S. Slack-Smith, WAM 1306–86. 1 female ovig. (SL 14.9 mm), W of Lacepede Arch, FRV *Soela*, sta. S01/84/050, 16°41.8'S, 120°07.3'E, 434–430 m, 9 Feb 1984, WAM 1296–86. 2 females (SL 9.3, 11.8 mm), 1 female ovig. (SL 13.5 mm), W of Lacepede Arch, FRV *Soela*, sta. 01/84/90, 16°55'S,

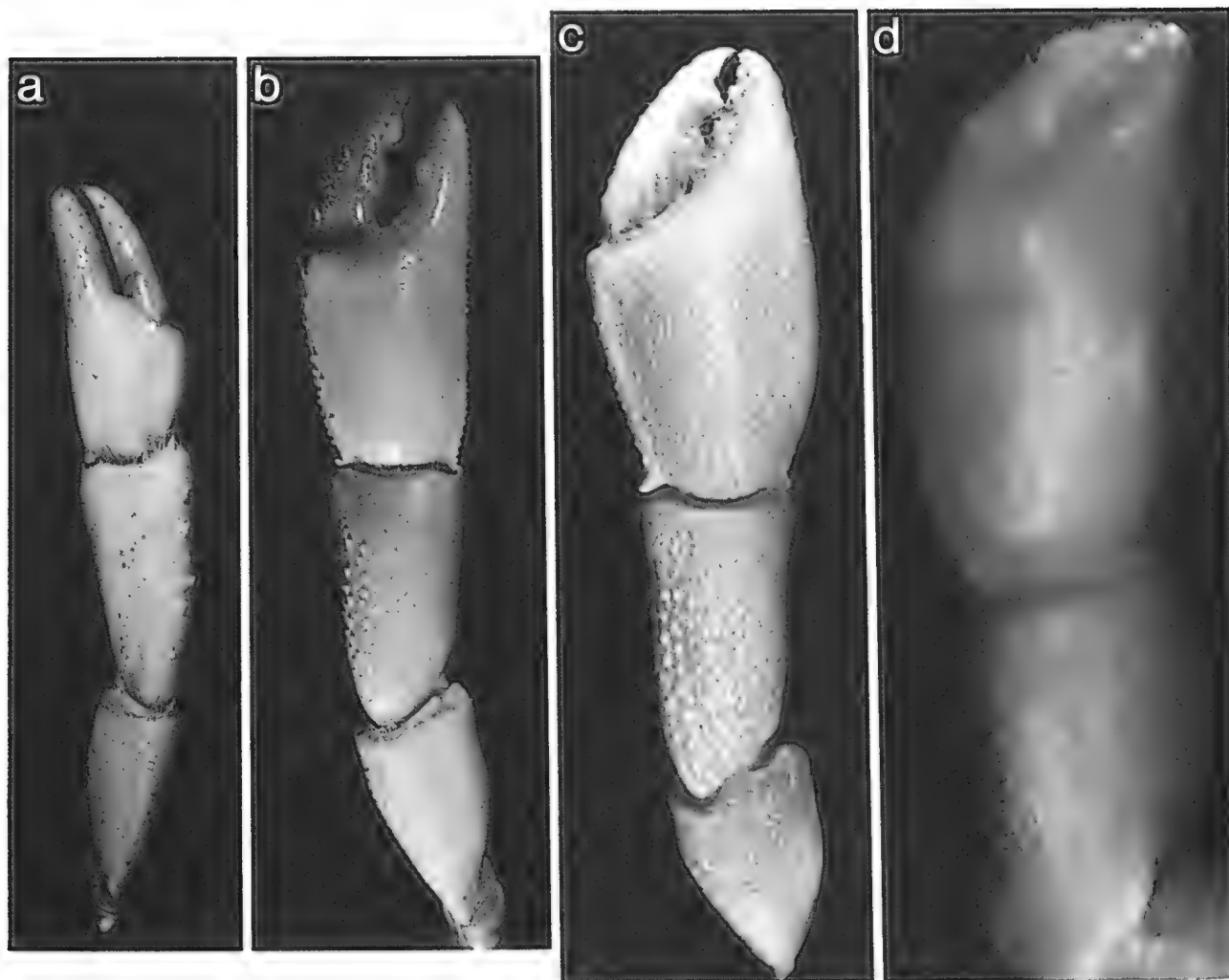


Fig. 3. *Sympagurus brevipes* (De Saint Laurent, 1972): a, left cheliped, denuded (1.1 $\times$ ); b, right cheliped, denuded (1.1 $\times$ ). *Sympagurus papposus* n.sp.: c, right cheliped, denuded (2.0 $\times$ ); d, right cheliped with setation (2.0 $\times$ ). (a,b, male [SL 18.3 mm], Western Australia, NTM; c, paratype male [SL 12.1 mm], Western Australia, NTM Cr 006863; d, paratype male [SL 13.0 mm], Western Australia, USNM 270108).

119°54'E, 435–434 m, 18 Feb 1984, coll. S. Slack-Smith, WAM 1437–86. 1 male (SL 12.3 mm), FRV *Courageous*, sta. 12, 16°55'S, 119°55'E, 429–430 m, 19 Aug 1983, colls. P. Berry and N. Sinclair, WAM 1012–85. 1 female (SL 14.1 mm), W of Lacepede Arch, FRV *Soela*, sta. S01/84/089, 16°55.1'S, 119°54.6'E, 432–434 m, 18 Feb 1984, WAM 1305–86. 1 male (SL 7.0 mm), W of Lacepede Arch, FRV *Soela*, sta. 01/84/096, 16°55.4'S, 119°52.5'E, 431–432 m, 19 Feb 1984, WAM 1308–86. 1 male (SL 11.6 mm), 2 females (SL 8.5, 10.8 mm), W of Lacepede Arch, FRV *Soela*, sta. S001/84/105, 16°56.9'S, 119°52'E, 432 m, 21 Feb 1984, coll. S. Slack-Smith, WAM 1297–86. 2 females (SL 6.4, 11.8 mm), W of Lacepede Arch, FRV *Soela*, sta. 01/84/105, 16°56.9'S, 119°53.8'E, 432 m, 21 Feb 1984, coll. S. Slack-Smith, WAM 1293–86. 1 male (SL 18.3 mm), 1 female (SL 15.9 mm), Scampi trawl grounds, *Comoc Endeavour*, sta. WH 85–15, 17°22'S, 118°38'E, 430 m, 2 Nov 1985, NTM Cr 011527. 1 male (SL 8.9 mm), FV *Courageous*, sta. 10, 17°28'S, 118°52'E, 428–435 m, 18 Aug 1983, colls. P. Berry and N. Sinclair, WAM 1281–85. 1 female (SL 12.0 mm), Scampi trawl grounds, *Comoc Endeavour*, sta. WH 85–18, 17°35'S,

118°43'E, 445 m, 3 Nov 1985, NTM Cr 006850. 1 female (SL 8.9 mm), Northwest Shelf, FRV *Soela*, sta. 0184/30, 17°41.2'S, 118°42.5'E, 357 m, NTM Cr 006859. 2 males (SL 10.6, 14.0 mm), 1 female (SL 12.1 mm), W of Broome, FRV *Soela*, sta. 01/84/122, 17°59–54'S, 118°23–29'E, 390 m, 24 Feb 1984, WAM. 2 males (SL 24.7, 26.0 mm), North West Shelf, sta. T7, 17°59.4'S, 118°18.4'E, 406–416 m, coll. A.J. Bruce, NTM Cr 006251, 006249. 1 female ovig. (SL 14.8 mm), 44 mi (81.4 km) SW of Imperieuse Reef, FRV *Soela*, sta. S02/82/17A, 18°01'S, 118°17'E, 410–420 m, 3 Apr 1982, WAM 1357–86. 1 male (SL 9.8 mm), FV *Courageous*, sta. 3, 18°01'S, 118°13'E, 450–452 m, 12 Aug 1983, colls. P. Berry and N. Sinclair, WAM 1283–85. 2 females (SL 6.9, 12.1 mm), FV *Courageous*, sta. 2, 18°05'S, 118°10'E, 401–400 m, 17 Aug 1983, WAM 1287–85. 1 female (SL 9.8 mm), SW of Imperieuse Reef, FV *Courageous*, sta. 53, 18°03'S, 118°16'E, 400 m, 28 Aug 1983, colls. P. Berry and N. Sinclair, WAM 1324–86. 1 female (SL 10.1 mm), W of Roebuck Bay, FRV *Soela*, sta. 01/84/121, 18°04'S, 118°04'E, 400–396 m, 24 Feb 1984, coll. S. Slack-Smith, WAM 1322–86. 1 male (SL 11.0 mm), W of Roebuck Bay, FRV *Soela*, sta. S01/84/121,

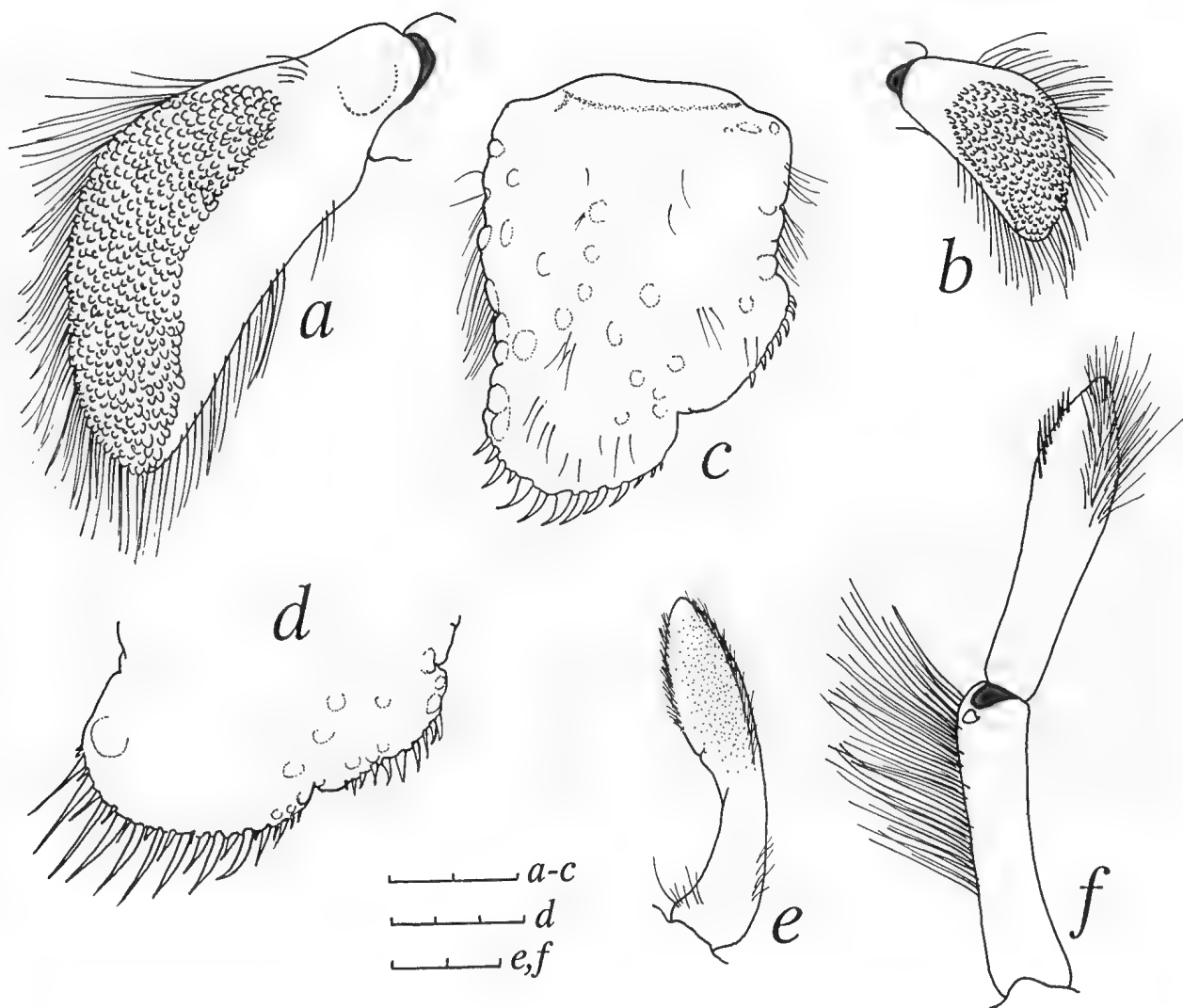
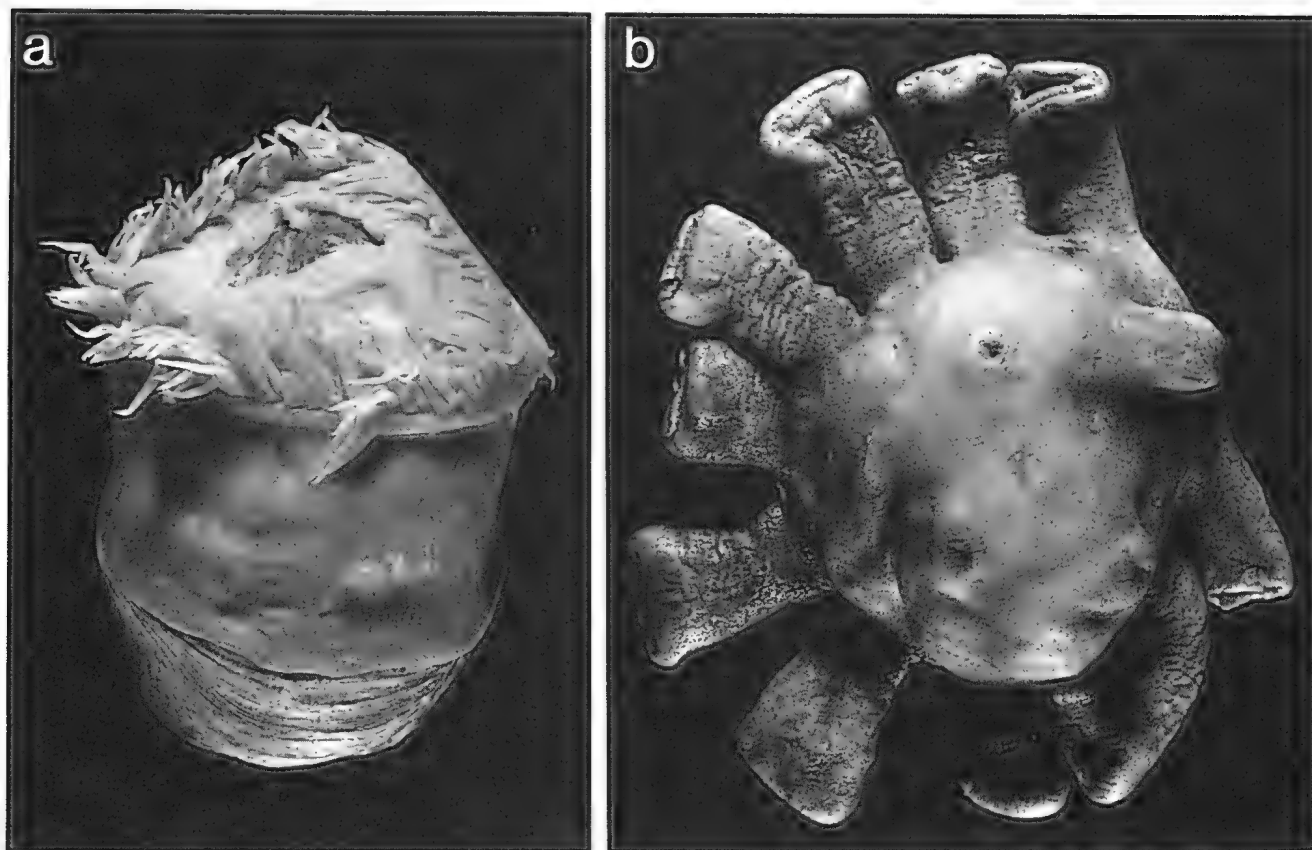


Fig. 4. *Sympagurus brevipes* (De Saint Laurent, 1972). a, b, exopod of uropods, dorsal: a, left; b, right; c, telson; d, posterior lobes of telson; e, male left 1st gonopod, mesial; f, male left 2nd gonopod, anterior. Scales = 2 mm (a-c), 3 mm (d), and 2 mm (e, f). (a-c, holotype male [SL 12.9 mm], Indonesia, ZMA De103.103; d, paratype female [SL 14.0 mm], Philippines, USNM 168913; e, f, male [SL 22.0 mm], Western Australia, AM P39443).

18°04'S, 118°14'E, 400–396 m, 24 Feb 1984, WAM 1137–86. 1 male (SL 12.0 mm), 1 female (SL 9.2 mm), FV *Courageous*, sta. 26, 18° 05'S, 118°08'E, 440–442 m, 22 Aug 1983, colls. P. Berry and N. Sinclair, WAM 1282–85. 1 female (SL 10.4 mm), 56 mi (103.6 km) SW of Imperieuse Reef, FRV *Soela*, sta. SO 18/02/82, 18°08'S, 118°06'E, 404 m, 3 Apr 1982, WAM 1097–86. 1 male (SL 22.0 mm), 190 km NW of Port Hedland, FRV *Soela*, sta. S02-02-36137/38, 18°16'S, 118°12'E, 298–320 m, 10 Apr 1982, coll. J. Paxton, AM P39443. 1 female (SL 5.2 mm), North West Shelf, FRV *Soela*, sta. 0184/16, 18°37.4'S, 117°02.4'E, 504–508 m, 31 Jan 1984, NTM Cr 006857. 2 males (SL 19.7, 24.2 mm), 22 km NW of Port Hedland, FRV *Soela*, sta. S02-82-46, 18°41'S, 116°46'E, 508 m, 13 Apr 1982, coll. J. Paxton, AM P39442. 2 females ovig. (SL 12.0, 18.0 mm), FRV *Soela*, sta. NWS-6, 18°41.6'S, 117°18.6'E, 320–360 m, 25 Apr 1983, NTM Cr 011528. 1 female (SL 8.1 mm), North West Shelf, FRV *Soela* 0283, sta. NWS-7, 392–400 m, 25 Apr 1983, coll. A.J. Bruce, NTM Cr 000765. 1 female (SL 8.8 mm), North West Shelf,

FRV *Soela*, CSIRO cruise 0184, sta. NWS-36 T/10, 19°15.5'S, 115°38'E, 404 m, 29 Jan 1984, coll. A.J. Bruce, NTM Cr 000668. 2 males (SL 21.5, 24.5 mm), 2 females (SL 12.8, 19.2 mm), North West Shelf, FRV *Soela*, sta. S01-84-61, 11 Feb 1984, coll. T. Ward, AM P39451.

NORTHERN TERRITORY: 1 female (SL 15.2 mm), Arafura Sea, 09°20'S, 131°04'E, 295 m, 9–16 Jul 1988, coll. Barry Clemens, NTM Cr 007007. 1 male (SL 24.1 mm), Timor Sea, 09°45'S, 129°59'E, 300 m, 23 Sep 1987, coll. NT Fisheries, USNM. 1 female ovig. (SL 17.7 mm), Timor Sea, *Endeavour Pearl*, Shot 1, 09°46'S, 130°15'E, 267 m, 16 Sep 1987, USNM. 1 female (SL 13.3 mm), 1 female ovig. (SL 14.0 mm), Scampi trawl grounds, *Comoc Endeavour*, sta. WH 85–17, 17°23'S, 118°57'E, 430 m, 3 Nov 1985, coll. W. Houston, NTM Cr 006849. 1 female (SL 9.6 mm), Scampi trawl grounds, *Comoc Endeavour*, sta. WH 85–28, 18°00'S, 118°16'E, 430 m, 6 Nov 1985, coll. W. Houston, NTM Cr 006851.



**Fig. 5.** Symbionts of *Sympagurus brevipes* (De Saint Laurent, 1972) (a), and *S. papposus* n.sp. (b). a, actinian, probably *Stylobates* sp. (0.8×); b, zoanthid *Epizoanthus* sp. (1.0×). (a, Western Australia, AM P39442; b, New South Wales, AM P21008).

QUEENSLAND: 1 male (SL 9.2 mm), off Innisfail, CIDARIS I, sta. 43–3, 17°35'S, 146°52.2'E, ORV *Franklin*, 480–504 m, 15 May 1986, coll. JCU, QM W16500. 2 juvs. sex indet. (SL 2.4, 3.5 mm), off Tully, 17°51.8'S, 147°07.9'E, epibenthic sledge, ORV *Franklin*, sta. 47–2, 503–497 m, 16 May 1986, coll. JCU, QM. 1 male (SL 9.0 mm), 1 female (SL 5.7 mm), off Tully, CIDARIS I, sta. 47–2, 17°52'S, 147°08'E, epibenthic sledge, ORV *Franklin*, 503–497 m, 16 May 1986, coll. JCU, QM W16501.

**Other material.** (For meaning of asterisks see Materials and Methods). SOUTH CHINA SEA: 1 female (SL 8.6 mm), SE of Hong Kong, *Albatross*, sta. 5301, 20°37'N, 115°43'E, 380 m, 8 Aug 1908, USNM 168916\*.

PHILIPPINES: 1 female (SL 4.4 mm), W of Luzon, *Albatross*, sta. 5438, 15°54'42"N, 119°44'42"E, 543 m, 8 May 1909, USNM 168917\*. 1 female (SL 14.0 mm), Luzon, off Sombrero Is., *Albatross*, sta. 5111, 13°45'15"N, 120°46'30"E, 432 m, USNM 168913\*. 1 female (SL 13.3 mm), Luzon, Tayabas Bay, off San Andres Is., *Albatross*, sta. 5221, 13°38'15"N, 121°48'15"E, 353 m, 24 Apr 1908, USNM 168914\*. 1 female (SL 13.7 mm), Mindoro Is., off Balanja Point, *Albatross*, sta. 5260, 12°25'35"N, 121°31'35"E, 428 m, 3 Jun 1908, USNM 168915\*. 1 female (SL 8.8 mm), N Mindanao, *Albatross*, sta. 5506, 08°40'N, 124°31'45"E, 479 m, 5 Aug 1909, USNM 168918\*.

INDONESIA: 1 male (SL 8.4 mm), Borneo (Kalimantan), Sibuko Bay, off Silungan Is., *Albatross*, sta. 5592, 04°12'44"N, 118°27'44"E, 558 m, 29 Sep 1909, USNM 168919\*. 1 male (SL 11.6 mm), 4 females (SL 5.9–9.2 mm), same sta. data as holotype, ZMA De 103.104\*. 1 male juv. (damaged), Siboga Exp., sta. 316, 07°19.4'S, 116°49.5'E, 538 m, coll. M. Weber, ZMA De 103.107\*. 1 male juv. (SL 4.7 mm), 1 female juv. (4.2 mm), Siboga Exp., sta. 45, 07°24'S, 118°15.2'E, 794 m, coll. M. Weber, ZMA De 103.106\*. 1 male (SL 21.2 mm), Siboga Exp., sta. 5, 07°46'S, 114°30.5'E, 330 m, coll. M. Weber, ZMA De 103.105\*.

**Diagnosis.** First 11 pairs of gills intermediate (Fig. 2e); vestigial pleurobranchs on last thoracic somite occasionally obsolete or missing in small specimens SL < 5.5 mm. Shield (Fig. 2a) broader than long; dorsal surface weakly calcified medially; rostrum triangular, with low dorsal ridge; anterior margins straight; lateral projections broadly rounded, often nearly obsolete; ventrolateral margin unarmed; posterior margin broadly rounded. Ocular peduncles more than half length of shield; ocular acicles subtriangular, terminating in spine (rarely bifid on one side); corneae slightly dilated. Sternite of 3rd maxillipeds with spine on each side of midline. Epistomial spine straight, often absent. Antennular peduncle exceeding distal margin of corneae

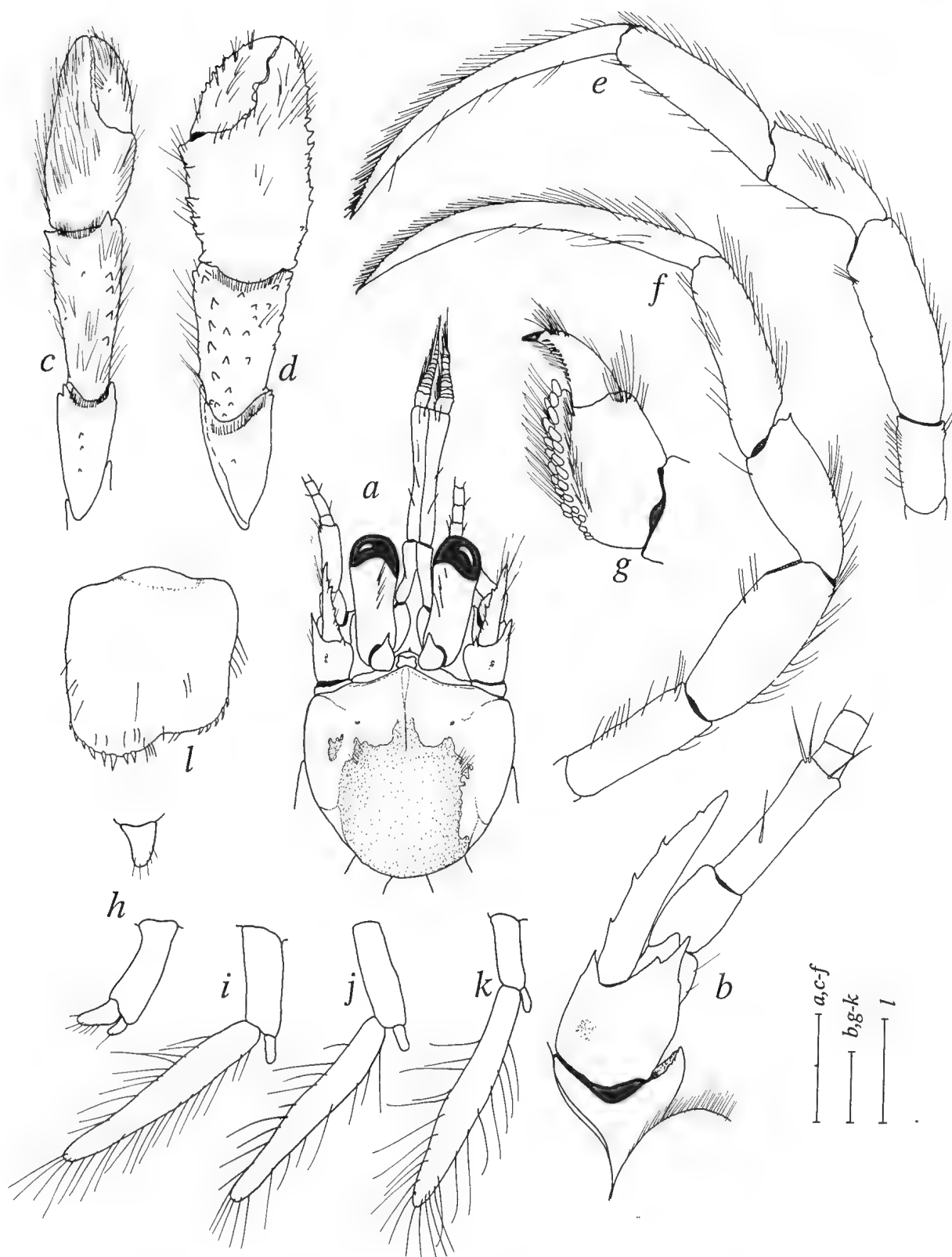


Fig. 6. *Sympagurus brevipes* (De Saint Laurent, 1972), juvenile sex indet. (SL 4.1 mm), Western Australia, USNM 270112. a, shield and cephalic appendages; b, right antennal peduncle, lateral; c, left cheliped; d, right cheliped; e, left 2nd pereopod, lateral; f, left 3rd pereopod; g, propodus and dactyl of left 4th pereopod; h-k, pleopods: h, 2nd (upper is right, lower is left); i, left 3rd; j, left 4th; k, left 5th; l, telson. Scales = 2 mm (a,c-f), 0.5 mm (b,g-k), 1 mm (l).

by full length of ultimate segment. Antennal peduncle at most slightly exceeding distal margin of cornea; 4th segment unarmed; 3rd segment with strong ventromesial distal spine; 2nd segment with dorsolateral distal angle produced, terminating in strong spine with 3 small spines dorsally; acicles reaching at most distal margin of cornea, mesial margin armed with 9 to 12 spines; flagellum with few setae < 1 flagellar article in length. Chelipeds markedly dissimilar, with numerous tufts of setae (not shown in Fig. 3a,b) obscuring surfaces. Right cheliped (Fig. 3b) with chela varying from 1.5 to more than twice as long as broad in larger individuals; fingers weakly curved ventromesially, dactyl with weakly concave ventromesial face; dorsal and ventral faces of palm unarmed, smooth except for tufts of setae; mesial and lateral faces of palm rounded, with lateral and dorsomesial rows of spines; carpus with numerous small tubercles or spines on dorsal surface. Left cheliped (Fig. 3a) with chela unarmed, well calcified; carpus with dorsodistal spine, and dorsal row of 2 to 4 well-spaced spines. Ambulatory legs (Fig. 2b,c) exceeding tip of extended right cheliped; dactyl about twice as long as propodus, with ventromesial irregular row of 20 to 25 minute corneous spines, dorsal row of long setae, and 3 dorsomesial oblique rows of long setae distally; carpus with small dorsodistal spine; ischium and merus of 2nd pereopod with row of few small tubercles or spines. Anterior lobe of sternite of 3rd pereopods unarmed or with 1 marginal spine, setose. Fourth pereopod with dactyl terminating in corneous claw; propodal rasp of adults consisting of 4 to 6 rows of ovate scales (Fig. 2d), and of juveniles (SL < 5.5 mm) of 1 or 2 rows of ovate scales (Fig. 6g). Uropods and telson (Fig. 4a-d) markedly asymmetrical; telson with weak transverse suture separating anterior and posterior lobes, dorsal surface with low blister-like tubercles; posterior lobes separated by V-shaped cleft, terminal margins armed with often long corneous spines, spines on left side strongly curved laterally, usually much longer in females than in males (Fig. 4c,d). Male 1st gonopods (Fig. 4e) each with concave distal lobe; 2nd gonopods (Fig. 4f) each with distal segment nearly flat, rounded distally, often with rudimentary exopod. Females with vestigial right 2nd pleopod.

**Habitat and symbiotic associations.** Lives associated with an actinian (Fig. 5a) that secretes a carcinoecium similar to that produced by species of *Stylobates* (see Fautin Dunn *et al.*, 1980; Fautin Dunn & Liberman, 1983; Fautin, 1987).

**Distribution.** Indo Pacific: Zanzibar; Indonesia; Philippines; and Australia. Depth: 267 to 794 m.

**Remarks.** As pointed out by the De Saint Laurent (1972: 106), specimens of this species can attain a large size. The largest specimen measured during the present study has a SL of 26.0 mm, exceeding all other specimens of *Sympagurus* species. This species is among the most common of *Sympagurus* found in Australia but apparently is confined to the north.

**Comparison of juveniles and adults.** Juvenile specimens of *S. brevipes* that are as large or larger than adult specimens of other *Sympagurus* species are frequently encountered. As in other species in the genus, such as *S. dimorphus* (see Lemaître & McLaughlin, 1992), the morphology of juveniles of *S. brevipes* can be quite different from that of adults. The most important differences between juveniles and adults of this species are summarised below.

The ocular peduncles of juveniles are subequal in width throughout their length (Fig. 6a); the peduncles of adults are medially constricted (Fig. 2a). The antennal acicle of juveniles is armed mesially with usually four weak spines (Fig. 6b); the acicle of adults is armed with nine to 12 spines. Chelipeds of juveniles, when extended, have nearly the same length, the spines are weak, not numerous (Fig. 6c,d), and pilosity does not obscure the surfaces; chelipeds of adults are markedly different in distal extension, spination is strong, and pilosity is dense, obscuring the surfaces. The meri of the 2nd and 3rd pereopod in juveniles (Fig. 6e,f) are not as broad as those of adults (Fig. 2b). In juveniles, the propodal rasp of the 4th pereopod has two rows of scales (Fig. 6g), smaller specimens (SL < 3.5 mm) only one row; the rasp of adults has four or five rows (Fig. 2d). The 2nd to 5th pleopods of juveniles are paired, asymmetrical, the left biramous with a short endopod, the right uniramous (Fig. 6h-k). Juvenile males exhibit rudimentary paired 1st gonopods. Adults have gonopods or pleopods as indicated in the diagnosis. The terminal margin of the posterior lobes of the telson of juveniles are armed with few small spines (8, left lobe; 5, right lobe; Fig. 6l); the terminal margins of adults are armed with many spines (20+ on left lobe, 8 on right lobe). The vestigial pleurobranch on the last thoracic somite is occasionally absent in small juveniles (SL < 3.5 mm), whereas the pleurobranch is invariably present in adult specimens.

### *Sympagurus dimorphus* (Studer, 1883)

Fig. 7

*Eupagurus dimorphus* Studer, 1883: 24, figs 11, 12 (type locality: off Cape of Good Hope, South Africa, S.M.S. Gazelle, 34°13.6'S, 15°00.7'W, 211 m).

*Parapagurus dimorphus*.—De Saint Laurent, 1972: 108.

*Sympagurus dimorphus*.—Lemaître, 1989: 71, figs 36–38, 40E–H.—Lemaître, 1990: 229.—Lemaître, 1994: 412.—Lemaître & McLaughlin, 1992: 747, figs 1–5, tables 1, 2.

**Type material.** Syntypes, Museum für Naturkunde der Humboldt-Universität zu Berlin (not examined).

**Australian material.** NEW SOUTH WALES: 1 female (SL 5.3 mm), off Newcastle, FRV *Kapala*, 549 m, Apr 1971, AM P18027. 2 males (SL 4.2, 5.4 mm), E of Broken Bay, FRV *Kapala*, sta. K80-07-02, 329 m, 5 Oct 1976, AM P40387. 2 males (SL 4.6, 5.5 mm), E of Seal Rocks, FRV *Kapala*, sta. K78-14-09, 32°23'S, 152°59'E, 503 m, 20 Jul 1978, AM P40402. 1 male (SL 3.2 mm), Ulladulla-Bateman's Bay area,



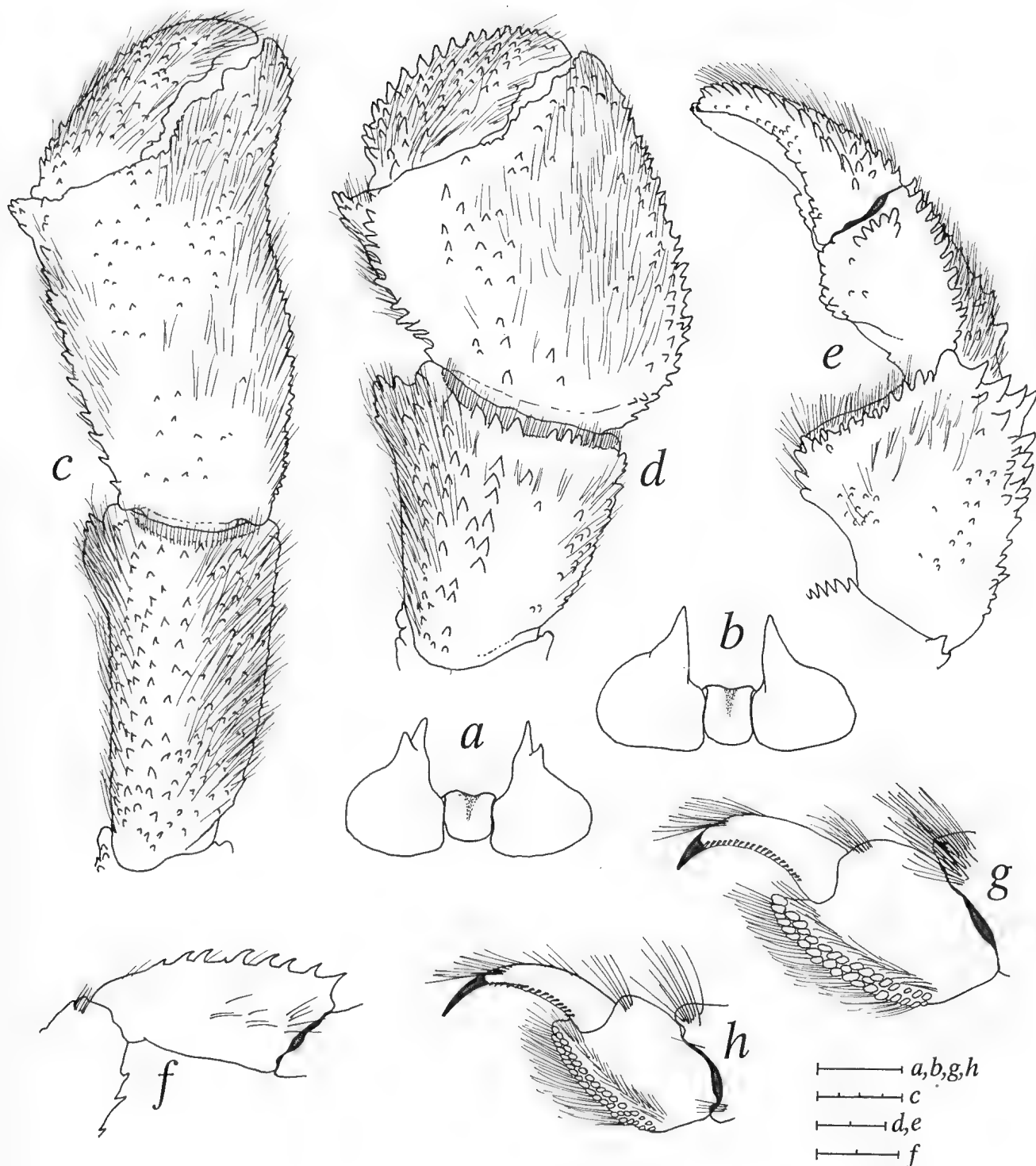


Fig. 7. *Sympagurus dimorphus* (Studer, 1883). a, b, ocular acicles, dorsal; c-e, carpus and chela of right cheliped: c, male; d, female; e, same, mesial; f, carpus of right 2nd pereopod, lateral; g, h, propodus and dactyl of left 4th pereopods, lateral: g, male; h, female. Scales = 1 mm (a, b, g, h), 4 mm (c), and 2 mm (d, e, f). (New Zealand: a, d-f, female [SL 8.1 mm], NMNZ Cr 3204; b, male [SL 8.4 mm], NMNZ Cr 3204; c, g, male [SL 9.2 mm], New Zealand, NMNZ Cr 8472; h, female [SL 6.9 mm], NMNZ Cr 3204).

FRV *Kapala*, sta. K77-03-07/08, 35°32'S, 15°47'E, 549 m, 28 Apr 1977, AM P40398. 1 female (SL 3.7 mm), SE of Gabo Is., FRV *Kapala*, sta. K75-03-02, 37°45'-38'S, 150°12'-16'E, 402-439 m, 10 Jul 1975, AM P20820.

VICTORIA: 1 male (SL 6.9 mm), 40 mi (74 km) S of Cape Everard, 400 m, Oct 1914, AM E.6153. 2 males (SL 5.2, 7.5 mm), off Gabo Is., 365 m, 11 Nov 1913, AM E.4771. 1 female (SL 5.5 mm), eastern slope, Bass Strait, 128-146 m, 29 Nov 1913, AM E.4827. 2 females (SL 4.6, 4.7 mm), off SE Victoria, 38°14.9'S, 149°26.1'E, CSIRO cruise FR5/86, SLOPE 34, 800 m, 23 Jul 1986, NMV J16208. 2 males (SL 5.2, 6.6 mm), 6 females ovig. (SL 5.2-6.3 mm), S of Point Hicks, Eastern Bass Strait, HMS *Kimbla*, sta. K7/73-8, 38°16'S, 149°26'E, 512 m, 21 Nov 1973, NMV J12126, J16190. 1 male (SL 5.8 mm), sta. MFG 15, Bass Strait, off Portland, 38°50'S, 141°46'E, 600 m, 6 Mar 1980, coll. M. Gomon *et al.*, NMV J40405. 3 males (SL 4.2-4.6 mm), 3 females (SL 3.7-4.4 mm), off eastern Victoria, CSIRO cruise FB5/86, SLOPE 46, 42°00.2'S, 148°37.7'E, 720 m, 27 Jul 1986, NMV J16191.

TASMANIA: 3 males (SL 4.2-7.0 mm), 2 females (SL 4.4, 5.3 mm), 1 female ovig. (SL 5.3 mm), off Babel Is., 124 m, 28 Oct 1912, AM E.3148, P3545. 2 males (SL 3.9, 7.2 mm), FRV *Soela*, S05/84/51, 41°15'S, 144°03'E, 520-480 m, 20 Oct 1984, coll. R. Wilson, NMV J11396. 1 female (SL 5.3 mm), FRV *Soela*, S05/84, 41°15'S, 144°08'E, 520 m, 20 Oct 1984, NMV J16201. 3 males (SL 6.0-8.2 mm), 1 female (SL 6.7 mm), 39 km NE of Cape Tourville, Tasmania Marine Station no. SLOPE 84, 41°53.54'S, 148°39.07'E, 732 m, 30 Oct 1988, coll. G.C.B. Poore *et al.*, NMV J16188, J40406. 3 males (SL 2.6-4.2 mm), 3 females ovig. (SL 4.1-4.3 mm), Oyster Bay, 110 m, [no date], AM P4484. 1 female ovig. (SL 5.3 mm), FRV *Soela*, S04/84/3, 42°41.9'S, 148°25.1'E, 440 m, 15 Aug 1984, NMV J16207. 3 males (SL 6.9-7.5 mm), E of Maria Is., F/S *Endeavour*, 91-182 m, 1915, AM E6420. 7 males (SL 2.0-5.5 mm), 7 females (SL 2.0-4.0 mm), 3 females ovig. (SL 4.3-4.4 mm), 25 km E of Port Davey, FRV *Soela*, sta. S05/84/60, 43°25.3'S, 145°39.8'E, 160 m, 21 Oct 1984, coll. R.S. Wilson, NMV J12110. 1 male (SL 3.7 mm), 3 megalopae (SL 1.5-1.7 mm), S of Hobart, *Dmitry Mendeleev*, 43°43'S, 147°46'E, 160 m, 20 Feb 1976, coll. J. Paxton, AM P21968. 1 male (SL 5.8 mm), 2 females ovig. (SL 5.0, 6.3 mm), S of Hobart, *Dmitry Mendeleev*, 43°48.2'S, 147°50'E, 720-755 m, 20 Feb 1976, coll. J. Paxton, AM P21962. 7 males (SL 4.8-6.0 mm), 3 females (SL 2.2-4.0 mm), 1 female ovig. (SL 4.2 mm), 44 unsexed (left in zoanthid carcinoecia), off Tasman Head, Bruny Is., 146-183 m, AM E.5180. 5 males (SL 7.3-7.6 mm), off South Cape, FS *Endeavour*, 137 m, 1914, AM E5176. 7 males (SL 7.3-7.8 mm), off South Cape, 137 m, AM E.5177. 1 female ovig. (SL 5.4 mm), off Maatsuyter Is., Jul 1958, NMV J16197.

**Other material.** NEW ZEALAND: 1 male (SL 6.8 mm), BS 812, (0.592), W of Hokianga Harbour, RV *Tangaroa*, NZOI sta. O.556, 35°37.6'S, 172°36.5'E, 657 m, 11 Jan 1981, NMNZ Cr 8466. 1 male (SL 9.7 mm), BS 805, WSW of Cape Maria van Dieman, RV *Tangaroa*, NZOI sta. O.549, 37°33.1'S, 177°33.8'E, 776-836 m, 11 Jan 1981, NMNZ Cr 8464. 2 females ovig. (SL 6.5, 6.6 mm), BS 846, (0.592), SE of Aldermen Is., RV *Tangaroa*, 37°04.3'S, 176°26.6'E, 807-872 m, mud, 23 Jan 1981, NMNZ Cr 8460. 3 males (SL 6.9-7.6 mm), 2 females (SL 2.7, 5.3 mm), BS 844, W of White Is., RV *Tangaroa*, NZOI sta. O.590, 37°10.8'S, 176°38.0'E,

685-705 m, mud, 23 Jan 1981, NMNZ Cr 8467. 1 female (SL 4.3 mm), 1 female ovig. (SL 9.2 mm), BS 761, about 37 km E of Mayor Is., RV *Tangaroa*, NZOI sta. R 119, 37°22.0'S, 176°37.2'E, 616-666 m, mud, 24 Jan 1979, NMNZ Cr 8475. 1 male (SL 5.0 mm), about 31 km WNW of Orete Point, Cape Runaway, RV *Tangaroa*, NZOI sta. R 123, 37°33.1'S, 177°33.8'E, 482-353 m, 25 Jan 1979, NMNZ Cr 8461. 1 female (SL 8.5 mm), Bay of Plenty, FV *Trinity*, 380-420 m, Nov 1987, NMNZ Cr 8433. 1 juv. sex indet. (SL 2.5 mm), E coast, North Is., RV *James Cook*, J10/60/86, 38°32.4'S, 178°48.4'E, 630 m, NMNZ CR 8426. 1 male (SL 9.0 mm), Mahia Peninsula, 38°47.5'S, 178°48.7'E, RV *James Cook*, J10/52/86, 769 m, 31 Aug 1986, coll. W.R. Webber, NMNZ Cr 8438. 1 male (SL 12.8 mm), Challenger Plateau, 38°53.6'S, 167°23.7'E, RV *James Cook*, J2/11/81, 841-847 m, 24 Jan 1981, NMNZ Cr 8441. 5 males (SL 3.3-9.3 mm), 1 female (SL 3.9 mm), BS 830, E of Cape Kidnappers, RV *Tangaroa*, NZOI sta. O.575, 39°52.8'S, 177°36.5'E, 785-882 m, mud, 21 Jan 1981, NMNZ Cr 8468. 1 female (SL 4.1 mm), Challenger Plateau, 40°06.3'S, 167°57.9'E, RV *James Cook*, J19/9/84, 919-922 m, 13 Nov 1984, NMNZ Cr 8454. 1 male (SL 9.2 mm), midway Castlepoint to Cape Tumagain, RV *James Cook*, J6/3/81, 40°49.8'S, 176°50.8'E, 752-688 m, 12 Apr 1981, coll. G.S. Hardy, NMNZ Cr 8456. 7 males (SL 6.2-10.5 mm), 1 female (SL 7.8 mm), 3 females ovig. (SL 6.1-8.0 mm), Hikurangi Trench, RV *James Cook*, J9/04/89, 41°21.6'S, 176°10.3'E, 710 m, 12 Sep 1989, NMNZ Cr 8451. 3 males (SL 6.8-9.2 mm), 5 females (SL 6.2-7.7 mm), 8 females ovig. (SL 5.6-7.3 mm), NW Westport, RV *James Cook*, J15/15/76, 41°25'S, 170°43'E, 212-332 m, 25 Sep 1976, USNM. 7 males (SL 6.9-10.6 mm), 6 females (SL 6.1-8.1 mm), 1 female ovig. (SL 8.1 mm), BS 672, off Turakirae Head, RV *Tangaroa*, NZOI sta. R 30, 41°31.4'S, 174°52.6'E, 533-225 m, mud and rocks, 15 Jan 1979, NMNZ Cr 8458, 8471, 8483. 10 males (SL 10.4-14.8 mm), 3 females (SL 7.5-10.5 mm), BS 643, 41°42.0'S, 175°15'E, RV *Tangaroa*, NZOI sta. R 1, Palliser slope, 461 m, mud, 9 Jan 1979, NMNZ Cr 8486, USNM. 1 male (SL 11.0 mm), 45 mi (83.2 km) NW of Perpendicular Point (Westland), RV *James Cook*, J15/17/76, 41°47'S, 170°29'E, 512-562 m, 26 Sep 1976, NMNZ Cr 8473. 1 male (SL 12.9 mm), 1 female ovig. (SL 10.9 mm), BS 668, about 43 km SE of Cape Campbell, RV *Tangaroa*, NZOI sta. R 26, 41°55.9'S, 174°43.2'E, 454-424 m, 14 Jan 1979, NMNZ Cr 8446. 4 males (SL 9.3-12.2 mm), 4 females (SL 3.4-6.4 mm), 2 females ovig. (SL 6.3-7.6 mm), BS 669, about 41 km SE of Cape Campbell, RV *Tangaroa*, NZOI sta. R 27, 41°55.8'S, 174°40.7'E, 434-446 m, 14 Jan 1979, NMNZ Cr 8479. 5 males (SL 7.8-14.8 mm), 5 females (SL 5.2-8.9 mm), 2 females ovig. (SL 8.5, 8.6 mm), off Westport, RV *James Cook*, J12/006/78, 42°33'S, 170°07'W, 400-473 m, 10 Dec 1978, NMNZ Cr 8448. 1 male (SL 6.3 mm), BS 560, 9.3 mi (17.2 km) S of Kaikoura Light, RV *Acheron*, 42°35'S, 173°41'E, 640 m, 28 Sep 1976, NMNZ Cr 8481. 3 males (SL 4.2-6.0 mm), 2 females (SL 4.8, 4.9 mm), BS 650, northern Mernoo slope, RV *Tangaroa*, NZOI sta. R 8, 42°38.2'S, 176°10.5'E, 999-984 m, 11 Jan 1979, NMNZ Cr 8465, 8482. 1 male (SL 4.8 mm), BS 664, Conway Trough, Kaikoura, RV *Tangaroa*, NZOI sta. R 22, 42°38.2'S, 173°36.0'E, 632 m, 13 Jan 1979, NMNZ Cr 8480. 1 female ovig. (SL 11.9 mm), NW of Chatham Is., COR/219/89, 42°49.8'S, 177°37.5'W, 815 m, 13 Aug 1989, NMNZ Cr 8455. 10 males (SL 3.6-10.2 mm), 2 females (SL 4.0, 5.2 mm), BS 546, about 24 mi (44.4 km) off Waiau River mouth, RV *Acheron*, 42°55'S, 173°43'E, 549-586 m, 18 Mar 1976, NMNZ Cr 8469. 5 males (SL 8.3-11.2 mm), 1 female (SL 7.1 mm), 22 females ovig. (SL 5.9-8.4 mm), BS 300, Turakirae Trench, 4.5 mi (8.3 km)

off Cape Turakirae, 640–658 m, 6 Sep 1972, NMNZ Cr 8439. 1 male (SL 7.8 mm), 3 females (SL 5.5–8.1 mm), 23 females ovig. (SL 6.1–8.5 mm), Turakirae trench, 2.5 mi (4.6 km) off Cape Turakirae, 640–658 m, 6 Sep 1972, NMNZ Cr 8445. 1 male (SL 12.2 mm), J09/15/77, 43°13.1'S, 173°51'E, 610 m, 18 Dec 1977, NMNZ Cr 3203. 7 males (SL 3.1–6.2 mm), 7 females (SL 3.9–6.4 mm), 29 females ovig. (SL 4.6–5.9 mm), 1 juv. sex indet. (SL 2.2 mm), BS 559, up steep wall of Pegasus Canyon, Pegasus Bay, RV *Acheron*, 43°14'S, 173°39'E, 1006–512 m, coral, 27 Sep 1976, NMNZ Cr 8450, 8463. 10 males (SL 4.2–6.4 mm), 2 females (SL 3.9, 4.8 mm), Taiaroa Trench off Otago Peninsula, RV *Acheron*, 768–722 m, 11 Aug 1974, coll. A.J. Black, NMNZ Cr 8474. 3 males (SL 10.3–12.2 mm), 5 females ovig. (SL 9.2–10.5 mm), Chatham Rise Carea, FV *Chiyo Maru*, 43°29'S, 176°34'W, 529–506 m, 15–19 Sep 1987, coll. R. Stewart, NMNZ Cr 8436. 2 males (SL 9.0, 12.5 mm), 1 female (SL 6.9 mm), 4 females ovig. SL 7.2–8.1 mm), Canterbury Bight, RV *James Cook*, J9/6/77, 44°40.7', 172°35.5'E, 370–360 m, 13 Dec 1977, NMNZ Cr 8476. 3 males (SL 8.5–10.5 mm), 2 females ovig. (SL 8.5, 9.6 mm), Canterbury Bight, RV *James Cook*, 44°44'S, 172°41'E, 402 m, 13 Nov 1970, NMNZ Cr 8440. 2 males (SL 12.2, 12.9 mm), 1 female (SL 10.8 mm), Solander Through, FV *Chiyo Maru*, haul 149, 46°30'S, 166°14.4'E, 573–545 m, 10 Sep 1987, NMNZ Cr 8442. 2 males (SL 12.8, 14.4 mm), 1 female ovig. (SL 13.1 mm), Solander Through, FV *Chiyo Maru*, haul 147, 46°31.9'S, 165°44.4'E, 320–346 m, coll. R. Stewart, NMNZ Cr 8428, 8434, 8435. 1 male (SL 12.1 mm), Puysegur Bank, FV *Chiyo Maru*, Haul 146, 46°44.4'S, 165°43.8'E, 566–296 m, 10 Sep 1987, coll. R. Stewart, NMNZ Cr 8449. 1 female (SL 12.0 mm), S of South Otago, FV *Chiyo Maru*, H.156, 47°02.8'S, 169°34.7'E, 309–331 m, 13 Sep 1987, coll. R. Stewart, NMNZ Cr 8427. 7 males (SL 8.6–14.2 m), 4 females (SL 5.9–12.4 mm), Northern Campbell Plateau, FV *Chiyo Maru*, H.155, 47°30.5'S, 169°14.7'E, 529–526 m, 13 Sep 1987, coll. R. Stewart, NMNZ Cr 8437, 8443, 8444. 9 males (SL 8.1–12.2 mm), 5 females (SL 8.7–11.8 mm), 1 female ovig. (SL 10.4 mm), Snares Is. Shelf, RV *James Cook*, J1/22/77, 48°12'S, 168°09'E, 700–706 m, 23 Jan 1977, NMNZ Cr 8457. 1 male (SL 9.7 mm), Snares Is. Shelf, RV *James Cook*, J1/24/77, 48°19'S, 167°55'E, 210–292 m, 23 Jan 1977, NMNZ Cr 8432. 1 male (SL 10.2 mm), Snares Is. Shelf, RV *James Cook*, J1/19/77, 48°50'S, 167°08'E, 514–535 m, 22 Jan 1977, NMNZ Cr 8478. 1 male (SL 12.1 mm), Auckland Is., RV *James Cook*, J2/16/80, 51°01.4'S, 166°19.2'E, 168–262 m, 30 Jan 1980, NMNZ Cr 8430.

**Diagnosis.** First 11 pairs of gills trichobranchiate. Shield usually as broad as long; dorsal surface often weakly calcified medially; rostrum rounded with broad low dorsal ridge; anterior margin concave; lateral projections subtriangular, with small terminal spine; ventrolateral margin unarmed; posterior margin broadly rounded. Ocular peduncles more than half length of shield; ocular acicles (Fig. 7a,b) subtriangular, terminating in strong simple or bifid spine; corneae slightly dilated. Sternite of 3rd maxilliped with spine on each side of midline. Epistomial spine short and straight, often absent. Antennular peduncle exceeding distal margin of corneae by nearly full length of ultimate segment. Antennal peduncle at most slightly exceeding distal margin of corneae; 4th segment with small dorsolateral distal spine; 3rd segment with strong ventromesial distal spine;

2nd segment with dorsolateral distal angle produced, terminating in strong multifid spine; acicles sinuous in dorsal view, usually not exceeding distal margin of corneae, mesial margin armed with 13 to 19 strong spines; flagellum distinctly overreaching right cheliped, with numerous setae 1 or 2 flagellar articles in length. Chelipeds markedly dissimilar, covered with moderately dense simple and plumose setae. Right cheliped massive (Fig. 7c–e), chela usually operculate; proportions and armature strongly affected by size and sexual dimorphism; fingers strongly curved ventromesially, dactyl with ventromesial face concave; dorsal surface of palm with numerous small tubercles or spines; dorsomesial and dorsolateral margins of palm well delimited by row of spines, dorsolateral margin often strongly curved. Left cheliped well calcified; palm with dorsomesial, dorsolateral, and often dorsomedial rows of small tubercles or spines; carpus with dorsal row of spines. Ambulatory legs usually overreaching extended right cheliped by about 0.25 length of dactyl, armature on meri, carpi and propodi frequently more developed on right than on left; dactyl shorter than propodus, with ventromesial row of 15 to 20 strong spinules, dorsal row of long setae, and 3 or 4 short dorsomesial oblique rows of setae on distally; carpus (Fig. 7f) with dorsal row of spines. Anterior lobe of sternite of 3rd pereopods with 1 to 3 small marginal spines, setose. Fourth pereopod (Fig. 7h,g) with dactyl terminating in sharp corneous claw; propodal rasp with 2 to 5 irregular rows of ovate scales. Uropods and telson markedly asymmetrical; telson with weak transverse suture, terminal margin separated by shallow, broad U-shaped sinus into unequal lobes armed with short corneous spines. Male 1st gonopods each with moderately concave distal lobe; 2nd gonopods each with distal segment spatulate, basal segment occasionally with short exopod. Females lacking 1st pleopods, or occasionally with rudimentary paired or unpaired 1st pleopods; with vestigial right 2nd pleopod.

**Distribution.** Southern hemisphere from 22°S to 57°S; in the Atlantic possibly as far north as Ascension Island. Depth: 91 to 1995 m.

**Remarks.** While examining the numerous material of this species from Australia and New Zealand, extreme variations were observed. The ocular acicles are frequently bifid (Fig. 7a). The armature of carpus and chela of the right cheliped, and carpi of walking legs, can be strong (Fig. 7c–f). On the 4th pereopod, the propodal rasp frequently exhibits two rows of ovate scales; the dactyl has a much longer, slenderer claw in females than in males (Fig. 7g,h). The type of housing used also varies, in some specimens consisting of a gastropod shell, in others of a zoanthid. Variations were particularly pronounced in the New Zealand material, but with such a considerable amount of morphological overlap with specimens from other regions that there is no character, or suite of characters, that can be used to justify separation at the species level.

*Sympagurus papposus* n.sp.

Figs 3c,d, 5b, 8-10

*Sympagurus dofleini*.—Lemaitre, 1994: 387 (in part) (Not *Sympagurus dofleini* [Balss, 1912]). (See remarks).

**Holotype.** Female ovig. (SL 14.3 mm), E of Broken Bay, FRV *Kapala*, sta. K75-01-02, 33°38'–34°S, 151°57'–152°01'E, 786–804 m, 2 Apr 1975, AM P44482.

**Paratypes from Australia.** WESTERN AUSTRALIA: 1 male (SL 7.8 mm), W of Cape Leveque, FRV *Soela*, sta. S01/84/092, 16°09.5'S, 120°08.8'E, 600–596 m, 18 Feb 1984, WAM 1241–86. 1 male (SL 12.1 mm), Scampi Trawl Grounds, *Comoc Endeavour*, sta. WH 85–15, 17°22'S, 118°38'E, 430 m, 2 Nov 1985, NTM Cr 006863. 1 male (SL 12.0 mm), North West Shelf, FRV *Soela*, sta. NWS-7, Scampi Shot 2, 18°32.2'S, 117°30.9'E, 392–400 m, 25 Jan 1983, coll. A.J. Bruce, NTM Cr 010911. 1 male (SL 13.0 mm), North West Shelf, FRV *Soela*, CSIRO, cruise 0184, sta. NWS-36 T/10, 19°15'S, 115°38'E, 404 m, 29 Jan 1984, coll. A.J. Bruce, USNM 270108. 2 females ovig. (SL 9.5, 10.8 mm), North West Shelf, FRV *Soela*, CSIRO, cruise 0184, sta. T8, 19°20.2'S, 115°44.1'E, 306–308 m, 29 Jan 1984, NTM Cr 000663, 000664. 3 males (SL 11.0–14.5 mm), West Shelf, FRV *Soela*, sta. S01-84-61, 11 Feb 1984, coll. T. Ward, AM P39452.

QUEENSLAND: 1 male (SL 14.2 mm), Marion Plateau, FRV *Soela*, sta. 0685-08, 22°55.1'S, 154°21.25'E, 590–606 m, 17 Nov 1985, NTM Cr 006852. 1 male (SL 14.0 mm), *Craigmin* Survey, sta. 26, 23°15.3'S, 154°21.7'E, 549 m, 4 Oct 1980, QM W10129. 1 female (SL 13.9 mm), FRV *Craig Mor*, shot 14, 23°18'S, 154°13'E, 530–585 m, 4 Oct 1980, NTM Cr 001157. 1 female ovig. (SL 11.0 mm), MV *Iron Summer*, shot 2, 27°19'11"S, 153°53'47"E, 600 m, 10 May 1983, trawled, QM W14338. 1 female ovig. (SL 13.3 mm), off N Stradbroke Is., MV *Iron Summer*, 27°35.5'S, 153°56.7'E, 520 m, 31 Mar 1983, trawled, coll. R. Noreton, QM W16520. 1 female ovig. (SL 14.0 mm), off N Stradbroke Is., MV *Iron Summer*, 27°36.5'S, 153°57'E, 550 m, 23 Nov 1982, trawled, G. Smith, QM W6518. 1 male (SL 16.6 mm), off N Stradbroke Is., MV *Iron Summer*, 27°40'S, 153°56.9'E, 530 m, 22 Nov 1982, trawled, G. Smith, USNM 270109. 1 male (SL 15.0 mm), off Southport, MV *Iron Summer*, 27°59.4'S, 154°00.1'E, 590 m, 31 Mar 1983, trawled, coll. R. Noreton, QM W16519.

NEW SOUTH WALES: 1 female (SL 8.0 mm), 30°31'–19°4'S, 161°54'2"–40°6"E, RV *Dmitry Mendeleev*, cruise 16, sta. 1245, 29 Dec 1975, NMV J11164. 1 female (SL 11.7 mm), E of Broken Bay, 33°30'–27'S, 152°05'–07'E, FRV *Kapala*, sta. K76-24-04, 819–823 m, 21 Dec 1976, AM. 3 males (SL 11.1–16.4 mm), 6 females ovig. (SL 11.8–14.5 mm), off Broken Bay, FRV *Kapala*, sta. K75-05-05, 33°32'–38'S, 152°00'–04'E, 823 m, 19 Aug 1975, AM P21008. 1 male (SL 16.3 mm), E of Broken Bay, FRV *Kapala*, sta. K77-23-12, 33°35'–33'S, 152°00'–02'E, 823 m, 8 Aug 1977, AM P26794. 3 males (SL 14.6–17.1 mm), E of Broken Bay, FRV *Kapala*, sta. K75-01-02, 33°38'–34'S, 151°57'–152°01'E, 786–804 m, 2 Apr 1975, AM P20495. 1 male (SL 17.0 mm), S of Sydney, FRV *Kapala*, sta. K07-01, 34°00'S, 151°43'E, 732 m, 6 Nov 1972, USNM 270110. 1 male (SL 10.4 mm), 40 km ESE of Ulladulla, FRV *Soela*, sta. S03/88/20, 35°31.29'S, 150°49.85'E, 910 m, Engels high-lift demersal, coll. M. Norman, NMV

J16189. 1 male (SL 7.9 mm), E of Eden, FRV *Kapala*, sta. K83-12-02, 37°36'S, 150°21'E, 860–960 m, 26 Sep 1983, AM P44031.

**Other Paratypes.** INDONESIA: 1 female ovig. (SL 9.7 mm), Indonesia, Java Sea, Siboga Exp., sta. 314, 07°36'S, 117°30.8'E, 694 m, 17 Jan 1900, ZMK.

WESTERN INDIAN OCEAN: 1 male (SL 11.0 mm), 1 female (SL 12.8 mm), Madagascar, *Vitiaz*, cruise 17, leg 3, sta. 2635, 25°05'S, 35°15'E, 228–205 m, 25 Nov 1989, LACM 95–17.1. 2 females ovig. (SL 11.2, 12.9 mm), Tulear [SW Madagascar], *Vitiaz*, cruise 17, sta. 2707, 33°01.8'S, 44°23.6'E, 910–925 m, 15 Dec 1988, USNM 270111.

**Description.** First 11 pairs of gills intermediate, weakly divided distally (Fig. 9f), or occasionally phyllobranchiate (Fig. 9e). Shield (Fig. 8a) as broad as long; dorsal surface frequently weakly calcified medially, with scattered short setae; rostrum broadly triangular, with short mid-dorsal ridge; anterior margins sinuose; lateral projections broadly rounded, often nearly obsolete; anterolateral margins slightly sloping; posterior margin broadly rounded. Anterodistal margin of branchiostegite rounded, unarmed, setose.

Ocular peduncles about half length of shield, with row of long setae dorsally. Cornea slightly dilated. Ocular acicles subtriangular, terminating in strong spine (occasionally bifid or trifid); separated basally by less than basal width of 1 acicle.

Antennular peduncle long, slender, exceeding distal margin of corneae by half length of penultimate segment. Ultimate segment twice or more as long as penultimate segment, naked or with scattered setae. Basal segment with strong ventromesial spine; lateral face with distal subrectangular lobe armed with 2 to 5 small spines, and strong spine proximally. Ventral flagellum with about 9 articles.

Antennal peduncle (Fig. 9d) exceeding distal margin of cornea by approximately half length of 5th segment. Fifth segment with scattered setae on lateral margin, and row of long setae dorsodistally. Fourth segment unarmed. Third segment with strong ventromesial distal spine. Second segment with dorsolateral distal angle produced, terminating in strong, multifid spine; mesial margin with spine on dorsodistal angle. First segment with small tubercle on lateral face; ventromesial angle produced, with 3 to 7 small spines laterally. Antennal acicles nearly straight (in dorsal view), exceeding distal margin of corneae by about 0.25 length of acicle, terminating in strong spine; mesial margin armed with 7 to 13 well-spaced spines, setose. Flagellum long, naked or with inconspicuous short setae less than half 1 flagellar article in length, exceeding extended right cheliped and ambulatory legs.

Mandible with 3-segmented palp. Maxillule (Fig. 9a,b) with external lobe of endopod weakly developed, internal lobe with 2 or 5 long setae. Maxilla with endopod slightly exceeding distal margin of scaphognathite. First maxilliped with endopod slightly exceeding exopod in distal extension. Second maxilliped without distinguishing characters. Third maxilliped (Fig. 9c) slender, distal 3

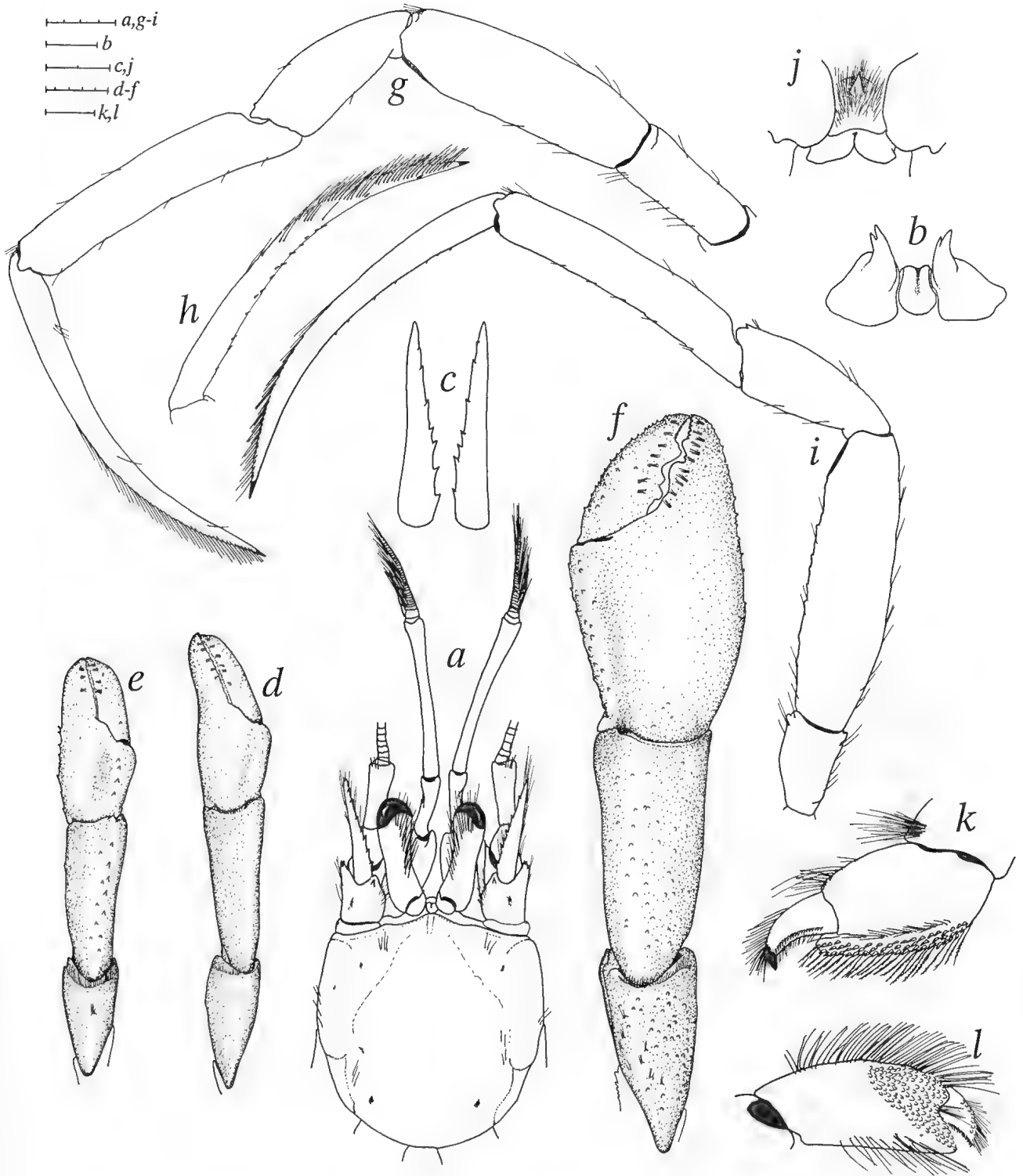


Fig. 8. *Sympagurus papposus* n.sp. a, shield and cephalic appendages; b, ocular acicles, dorsal; c, antennal acicles, dorsal; d,e, left cheliped, denuded; f, right cheliped, denuded; g, left 2nd pereopod, lateral; h, dactyl of same, mesial; i, left 3rd pereopod, lateral; j, sternite of 3rd pereopods, ventral; k, propodus and dactyl of left 4th pereopod, lateral; l, propodus and dactyl of left 5th pereopod, lateral. Scales = 4 mm (a,g-i), 1 mm (b,k,l), 2 mm (c,j), 5 mm (d-f). (a,c,d,f-l, paratype male [SL 12.1 mm], Western Australia, NTM Cr 006863; b, paratype female [SL 14.5 mm], New South Wales, AM P21008; e, paratype male [SL 11.0 mm], Madagascar, LACM).

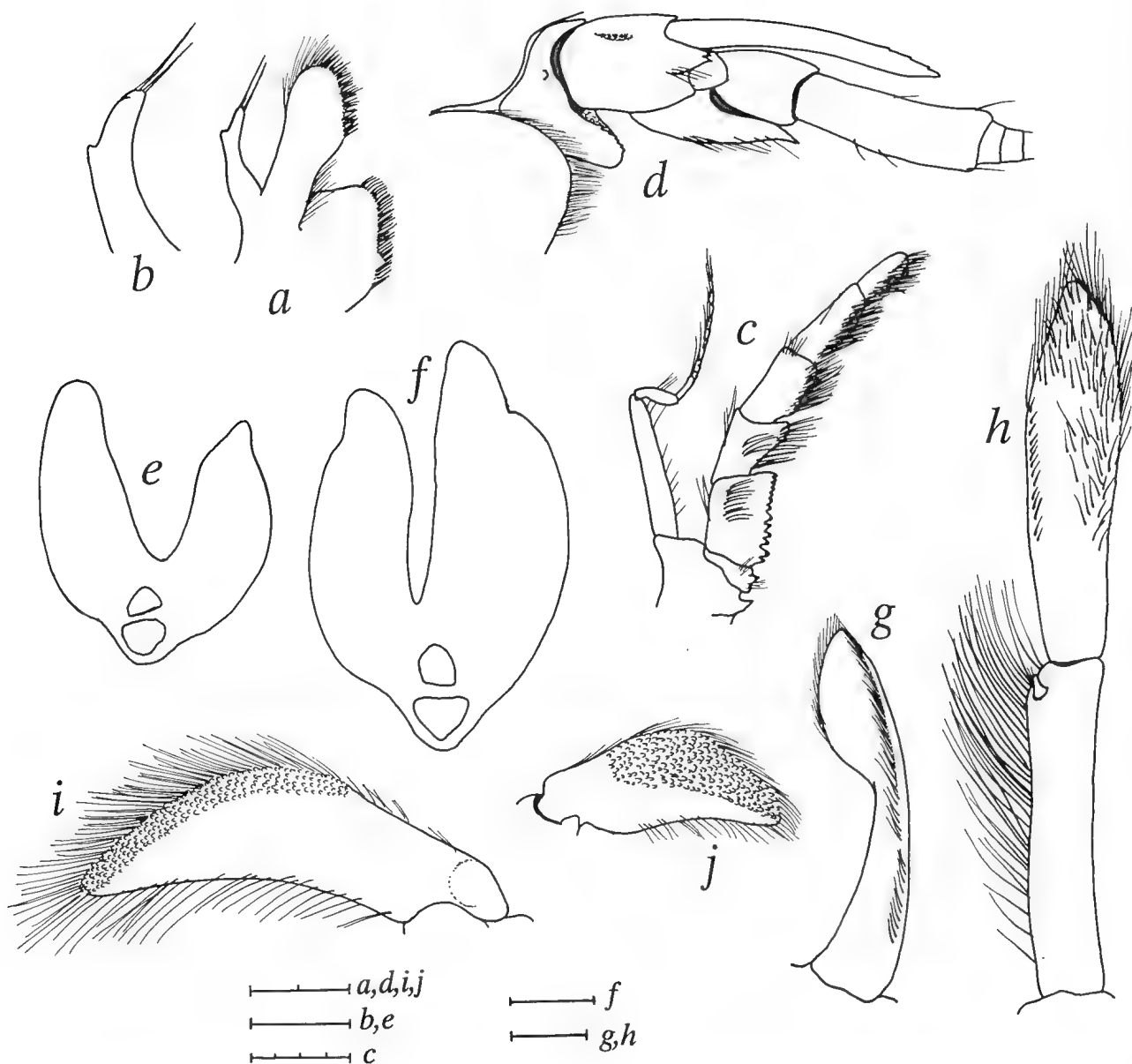


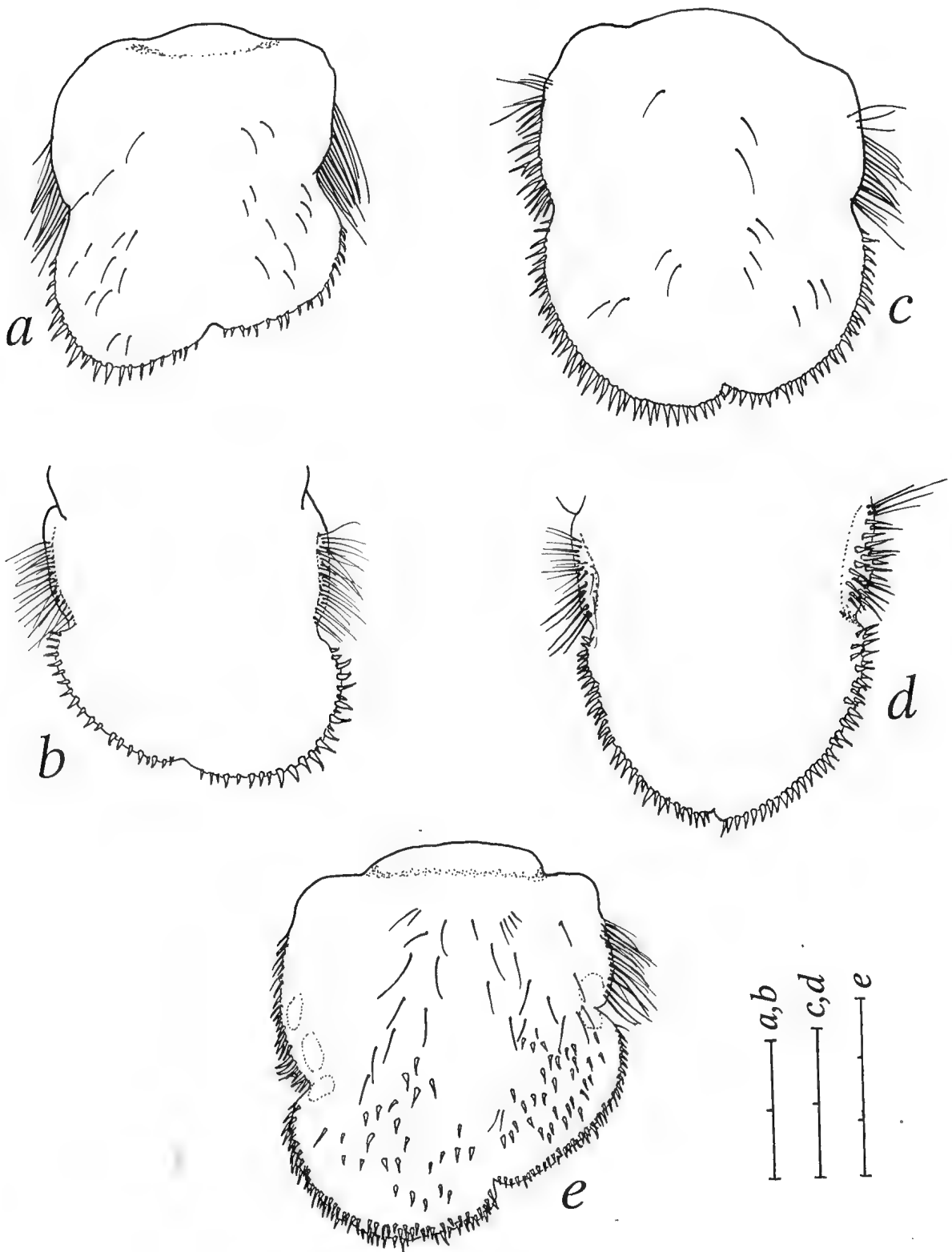
Fig. 9. *Sympagurus papposus* n.sp. a, left maxillule, internal; b, endopod of same; c, left 3rd maxilliped, internal; d, right antennal peduncle, lateral; e, f, branchia, transverse section; g, male left 1st gonopod, mesial; h, male left 2nd gonopod, anterior; i, j, exopod of uropods, dorsal: i, left, j, right. Scales = 2 mm (a,d,i,j), 1 mm (b,e, g,h), 4 mm (c), and 0.5 mm (f). (a–d,f–j, paratype male [SL 12.1 mm], Western Australia, NTM Cr 006863; e, paratype male [SL 14.0 mm], Queensland, QM W10129).

segments each 3 times as long as broad; crista dentata formed of 14 to 17 corneous-tipped teeth; coxa and basis each with small mesial tooth. Sternite of 3rd maxillipeds with small spine on each side of midline. Epistome with short, straight spine (often blunt), or unarmed. Labral spine present.

Chelipeds markedly dissimilar. Right cheliped (Fig. 8f) massive, with dense plumose setae. Fingers straight, terminating in small corneous claw; cutting edges each with irregularly-sized calcareous teeth; dorsal and ventral faces each with row of tufts of setae parallel to cutting edge. Dactyl subequal in length to palm, set at weakly

oblique angle to longitudinal axis of palm; mesial face rounded, with irregular rows of small spines; dorsal and ventral faces unarmed or at most with scattered small tubercles. Fixed finger with dorsal and ventral surfaces similar to dactyl. Palm about as long as broad; lateral and mesial faces rounded, with irregular rows of well-spaced small spines; dorsal and ventral surfaces smooth or at most with scattered tubercles. Carpus with small, well-spaced tubercles or spines on dorsal surface, dorsodistal margin unarmed; ventral surface with scattered small tubercles. Merus with dorsal surface similar to that of carpus; ventromesial margin with row of small spines.





**Fig. 10.** Telson of *Sympagurus papposus* n.sp. a, male, dorsal; b, same, ventral; c, female, dorsal; d, same, ventral; e, female, dorsal. Scales = 2 mm (a–d), and 3 mm (e). (a,b, paratype male [SL 12.1 mm], Western Australia, NTM Cr 006863; c,d, paratype female [SL 11.0 mm], Queensland, QM 14338; e, paratype female [SL 14.5 mm], New South Wales, AM P21008).



Coxa and ischium with small spines on ventral face; coxa with ventromesial row of setae.

Left cheliped (Fig. 8e,d) well calcified, with dense plumose setae. Fingers terminating in small corneous claws; dorsal and ventral surfaces smooth except for tufts of setae; cutting edge of dactyl with row of minute, fused corneous teeth; cutting edge of fixed finger with row of regularly-spaced, small calcareous teeth interspersed with minute, fused corneous teeth. Dactyl about 1.3 times as long as palm. Palm unarmed or occasionally with dorsomesial row of small tubercles or spines; ventral surface smooth or with scattered small tubercles. Carpus with dorsal surface usually unarmed (Fig. 8d), or occasionally with row of small tubercles or spines on dorsal margin (Fig. 8e); ventral surface smooth. Merus with dorsal surface unarmed or at most with small, low tubercles on dorsal margin; ventral face often with scattered small spines. Ischium with row of spines on ventral margin. Coxa unarmed but with ventromesial row of setae.

Ambulatory legs (Fig. 8g–i) similar from right to left, long, reaching to extended right cheliped; ischium, merus, carpus and propodus with scattered short setae. Dactyl about 1.4 times as long as propodus, terminating in sharp corneous claw; with dorsomesial row of long setae, and ventromesial row of about 17 to 30 small corneous spines. Carpus with small dorsodistal spine (often blunt). Merus of 2nd pereopods usually with row of small spines on ventral margin. Ischium and coxa unarmed. Anterior lobe of sternite of 3rd pereopods (Fig. 8j) with strong marginal spine (sometimes bifid), setose.

Fourth pereopod (Fig. 8k) semichelate. Dactyl subtriangular, terminating in sharp corneous claw, and ventrolateral row of small corneous spinules. Propodus with dorsal margin longer than dorsoventral height, rasp consisting of 2 or 3 rows of conical scales. Carpus with long setae on dorsal margin. Merus with rows of long setae on dorsal and ventral margins.

Fifth pereopod (Fig. 8l) semichelate. Propodal rasp extending to mid-length of segment.

Uropods and telson (Fig. 9i,j, 10) markedly asymmetrical. Telson with transverse suture; dorsal surface with scattered short setae; female with ventrolateral margin of left anterior lobe (occasionally also of right lobe) with cluster of corneous spines mixed with long bristle-like setae (Fig. 10c–e); male with ventrolateral margins of anterior lobes with long setae (Fig. 10a,b); both sexes with posterior lobes separated by U- or V-shaped cleft, terminal margin of lobes armed with corneous spines.

Males with paired 1st and 2nd gonopods well developed. First gonopods (Fig. 9g) each with ovate, weakly concave distal lobe. Second gonopods (Fig. 9h) each occasionally with rudimentary exopod on one side; distal segment nearly flat, setose on distomesial face, with row of short setae on lateral margin; basal segment with long setae on posterior face. Females rarely with rudimentary paired 1st pleopods, and vestigial 2nd right pleopod.

**Habitat and symbiotic associations.** Found living in zoanthids (probably *Epizoanthus* sp.; Fig. 5b).

**Distribution.** Indo Pacific: Madagascar; Indonesia; and Australia. Depth: 205 to 960 m.

**Etymology.** The specific name is derived from the Latin *pappus*, bristles, and refers to the characteristic spines and bristle-like setae on the telson in females of this species.

**Affinities.** This new species closely resembles *Sympagurus dofleini* (Balss, 1912) (see Lemaitre, 1994: 384, figs 7, 8). Female specimens of *S. papposus* can immediately be separated from male or females of *S. dofleini* by the ventrolateral armature of the anterior lobes of the telson. Females of the new species have the left anterior lobe (and sometimes also the right anterior lobe) armed ventrolaterally with a fringe or cluster of corneous spines mixed with long bristle-like setae (Fig. 10c–e). In *S. dofleini* the anterior lobes in both sexes have at most a row of long setae ventrolaterally. In contrast to females, males of the two species can be separated using only a number of subtle but distinct differences. The anterolateral projections of the shield are broadly rounded, often obsolete (Fig. 8a), on *S. papposus*, whereas they are broadly triangular and often terminate acutely on *S. dofleini*. The armature of the antennal acicles in the two species differs in that the spines are stronger and more broadly spaced on *S. papposus* (Fig. 9c) than *S. dofleini* (Fig. 11a). The gills of *S. papposus* are phyllobranchs, or intermediate branchiae with lamellae weakly divided distally (Fig. 9e,f); the gills of *S. dofleini* are intermediate with lamellae deeply divided distally (Fig. 11b). The distal lobe of the male 1st gonopod (Fig. 9g) is broader in *S. papposus* than *S. dofleini*.

Although there is some interspecific overlap in the range of variation of the armature of the carpus of the left cheliped in *S. papposus* and *S. dofleini*, this character can also be of help in differentiating the two species. The carpus of the left cheliped of *S. papposus* is usually unarmed dorsally (Fig. 8d), whereas the carpus of *S. dofleini* has a row of spines or tubercles on the dorsal margin (in addition to one or more dorsodistal spines).

The two species also differ in their habitat and symbiotic associations. *Sympagurus papposus* has been found living exclusively in large zoanthids (*Epizoanthus* sp.; Fig. 5b), whereas *S. dofleini* is commonly found living in large actinians of the genus *Stylobates* which secrete a chitinous pseudo-shell (see Fautin Dunn *et al.*, 1980; Fautin, 1987).

**Remarks.** During a study of parapagurids from French Polynesia, Lemaitre (1994: 387) mentioned under the distribution of *S. dofleini* that he had examined specimens of that species from Australia. However, reexamination of those specimens showed that they actually represent the new species *S. papposus*. *Sympagurus dofleini* has not been found to date in Australian waters.

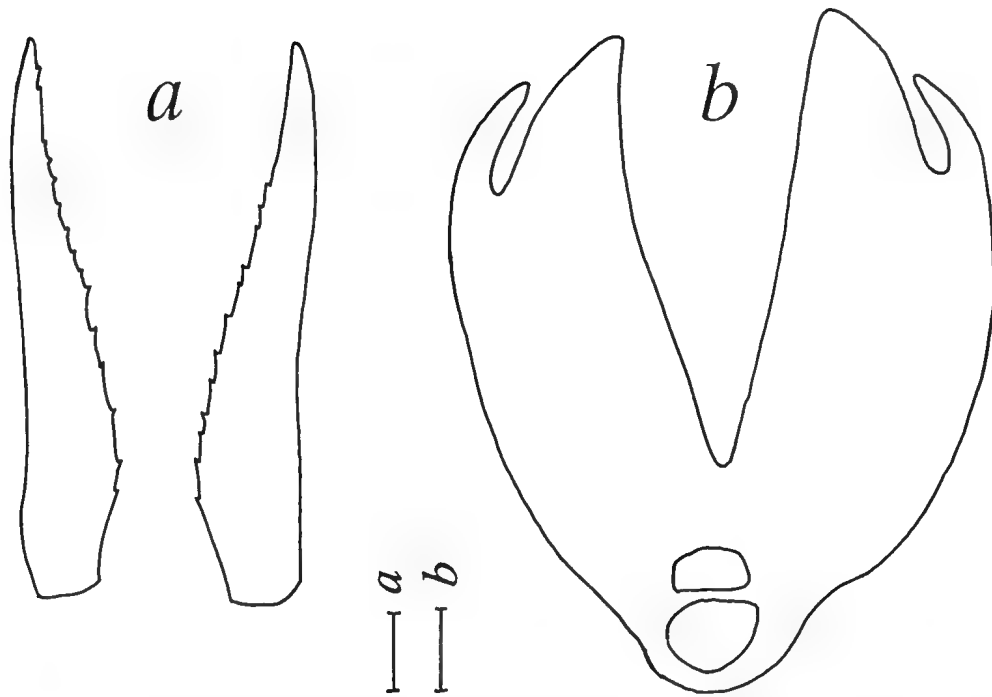


Fig. 11. *Sympagurus dofleini* (Balss, 1912). a, antennal acicles, dorsal; b, branchia, transverse section. Scales = 1 mm (a), and 0.5 mm (b). (Hawaiian Is.: a, male [SL 17.5 mm], USNM; b, female [SL 18.8 mm], BPBM).

***Sympagurus planimanus*** (De Saint Laurent, 1972)

*Parapagurus planimanus* De Saint Laurent, 1972: 109, figs 4, 22 (type locality: Indonesia, Flores Sea, Siboga Exp., sta. 45).

*Sympagurus planimanus*.—Lemaitre, 1989: 37; 1994: 387, figs 9, 10.

**Holotype.** Male (SL 6.3 mm), Indonesia, Flores Sea, Siboga Exp., sta. 45, 07°24'S, 118°15.2'E, 794 m, 6 Apr 1899, ZMA De103.111.

**Australian material.** WESTERN AUSTRALIA: 1 male (SL 5.7 mm), W of Cape Leveque, FRV *Soela*, 01/84/091, 16°08'S, 120°19.5'E, 550–544 m, 18 Feb 1984, coll. S. Slack-Smith, WAM 1096–86.

**Other material.** (For meaning of asterisks see Materials and Methods). INDONESIA: 1 male (SL 5.1 mm), 1 female (SL 4.4 mm), Borneo, Sibuko Bay, off Mabul Is., *Albatross*, sta. 5590, 04°10'50"N, 118°39'35"E, 567 m, 29 Sep 1909, USNM 168950\*. 2 males (SL 5.0–5.6 mm), Borneo, Sibuko Bay, off Sipadan Is., *Albatross*, sta. 5586, 04°06'50"N, 118°47'20"E, 635 m, 28 Sep 1909, USNM 168949\*. 3 males (SL 3.5–5.5 mm), 1 female (SL 3.6 mm), Molucca Passage, off Maren Is., *Albatross*, sta. 5618, 00°37'N, 127°15'E, 763 m, 27 Nov 1909, USNM 168951\*. 26 males (SL 3.1–6.1 mm), 20 females (SL 3.7–5.1), 16 females ovig. (SL 3.6–5.1 mm), same station data as holotype, ZMA De103.110\*.

**Diagnosis.** First 11 pairs of gills trichobranchiate. Shield as long as broad; dorsal surface weakly calcified medially;

rostrum broadly rounded, with low dorsal ridge; anterior margin straight; lateral projections broadly subtriangular, terminating bluntly; ventrolateral margin usually with small spine; posterior margin broadly rounded. Ocular peduncles more than half length of shield; ocular acicles subtriangular, terminating in strong spine; corneae slightly dilated. Sternite of 3rd maxilliped with small spine on each side of midline. Epistomial spine absent. Antennular peduncle exceeding distal margin of corneae by length of penultimate segment. Antennal peduncle at most exceeding distal margin of cornea by 0.25 length of 5th segment; 4th segment with dorsolateral distal spine; 3rd segment with strong ventromesial distal spine; 2nd segment with dorsolateral distal angle produced, terminating in strong spine; acicles reaching distal margin of corneae, mesial margin armed with 7 to 10 spines; flagellum with numerous setae 1 to 3 flagellar articles in length. Chelipeds dissimilar, with moderately dense setation. Right cheliped with chela less than twice as long as wide, fingers strongly curved ventromesially, dactyl with concave ventromesial face; dorsal and ventral faces of palm smooth; palm with dorsomesial and dorsolateral margins well delimited by row of spines, and rounded mesial face; carpus with numerous small tubercles or spines on dorsal surface. Left cheliped with chela unarmed, usually well calcified; carpus with dorsodistal spine. Ambulatory legs reaching to tip of extended right cheliped; dactyl about twice as long as propodus, with ventromesial row of about 5 well spaced corneous spinules, and dorsal and dorsomesial rows of long bristle-like setae; carpus with small dorsodistal

spine. Anterior lobe of sternite of 3rd pereopods unarmed. Fourth pereopod with long, curved corneous claw in large females (shield length > 4.0 mm); propodal rasp consisting of 1 row of ovate scales. Uropods and telson markedly asymmetrical; telson with weak median cleft separating anterior and posterior lobes; posterior lobes separated by broad shallow sinus, terminal margins armed with corneous spines. Male 1st gonopods each with concave distal lobe; 2nd gonopods each with distal segment nearly flat. Females with vestigial right 2nd pleopod.

**Distribution.** Western Pacific: South China Sea; Indonesia; and Australia. Depth: 100 to 794 m.

*Sympagurus soela* n.sp.

Figs 12, 13, 14a

*Sympagurus affinis*.—Lemaitre, 1994: 381 (in part) (Not *Sympagurus affinis* [Henderson, 1888]). (See remarks)

**Holotype.** Male (SL 6.5 mm), Marion Plateau, Queensland, FRV *Soela*, sta. 0685–30, 19°32.85'S, 152°34.8'E, 477–470 m, 23 Nov 1985, NTM Cr 006854.

**Paratypes.** QUEENSLAND: 1 male (SL 4.3 mm), 1 female ovig. (SL 3.7 mm), off Tully, ORV *Franklin*, sta. 47–2, 16°51.8'S, 147°0.8'E, 500 m, 16 May 1986, QM W16512. 1 female ovig. (SL 4.8 mm), off Tully, ORV *Franklin*, sta. 51–2, 18°03.9'S, 147°19.5'E, 689–704 m, 18 May 1986, QM W16505. 2 males (SL 6.4–6.5 mm), 2 females (SL 5.1, 5.2 mm), same sta. data as holotype, NTM Cr 006854.

NEW SOUTH WALES: 1 female (SL 5.2 mm), E of Wooli, FRV *Kapala*, sta. K77-13-11, 29°55'S, 153°41'E, 502 m, 23 Aug 1977, AM P40391. 2 males (SL 5.2, 5.8 mm), off Newcastle, 549 m, FRV *Kapala*, Apr 1971, USNM 270113. 1 male (SL 5.4 mm), transect between Sydney and Port Stevens, FRV *Kapala*, 366 m, Jul 1972, AM P19633. 1 male (SL 7.3 mm), 6–8 mi (11.1–14.8 km) E of Sydney, 274 m, 10 Aug 1972, coll. D. Griffin and J. Paxton, AM P40400. 2 males (SL 5.8, 6.7 mm), 1 female (SL 4.2 mm), 1 female ovig. (SL 5.4 mm), 52 km ENE of Nowra, ORV *Franklin*, sta. SLOPE 57, 34°43.55'S, 151°13.16'E, 450–345 m, 22 Oct 1988, colls. G.C.B. Poore *et al.*, NMV J16200.

**Description.** First 11 pairs of gills trichobranchiate. Shield (Fig. 12a) as broad as long, weakly calcified medially; dorsal surface with short rows of setae on each side of midline; rostrum broadly triangular, with short mid-dorsal ridge; anterior margins weakly concave; lateral projections broadly rounded; anterolateral margins slightly sloping; posterior margin broadly rounded. Anterodistal margin of branchiostegite rounded, unarmed.

Ocular peduncles more than half length of shield, with dorsal row of setae. Cornea slightly dilated. Ocular acicles subtriangular, terminating in strong multifid spine (Fig. 12b,c); separated basally by less than basal width of 1 acicle.

Antennular peduncle long, slender, exceeding distal margin of cornea by length of ultimate segment. Ultimate segment 1.5 times or more as long as penultimate segment, with scattered setae. Basal segment with strong ventromesial spine on lateral face, distal subrectangular lobe with 2 small spines and strong spine proximally. Ventral flagellum with about 9 to 13 articles

Antennal peduncle (Fig. 12d) slightly exceeding distal margin of cornea. Fifth segment unarmed, with row of setae on distolateral angle. Fourth segment usually unarmed (occasionally with small spine on dorsolateral distal angle). Third segment with strong ventromesial distal spine. Second segment with dorsolateral distal angle produced, terminating in strong, simple to bifid spine (often with small additional spine dorsally); mesial margin with spine on dorsodistal angle. First segment with small spine on lateral face; ventromesial angle produced, with 5 small spines laterally. Acicles slightly curved laterally (dorsal view), at most exceeding slightly distal margin of cornea, terminating in strong spine; mesial margin armed with row of 9 to 12 spines, setose. Flagellum long, reaching to tip of fingers of extended right cheliped, with scattered short setae less than 1 article in length.

Mandible with 3-segmented palp. Maxillule (Fig. 13a,b) with external lobe of endopod moderately developed, internal lobe with long seta distally. Maxilla with endopod exceeding distal margin of scaphognathite. First maxilliped with endopod exceeding exopod in distal extension. Second maxilliped without distinguishing characters. Third maxilliped (Fig. 13c) with crista dentata of 14 corneous-tipped teeth; basis and coxa each with small spine mesially. Sternite of 3rd maxillipeds with spine on each side of midline. Epistome unarmed. Labral spine present.

Chelipeds markedly dissimilar. Right cheliped (Figs 12f, 14a) covered with moderately dense setae (setae not shown in Fig. 12f). Fingers weakly curved ventromesially, tips crossed when closed and terminating in small corneous claws; cutting edges each with irregularly-sized calcareous teeth; dorsal surfaces with numerous sharp and blunt spines. Dactyl subequal in length to palm, set at oblique angle to longitudinal axis of palm; mesial margin well defined by row of spines; ventromesial face weakly concave. Palm about as long as broad, mesial and lateral faces rounded, with small spines; dorsal and ventral faces densely covered with sharp and blunt spines (less dense on ventral face and often on dorsal face in small specimens SL < 5.0 mm). Carpus with all faces densely covered with sharp and blunt spines (less dense on ventral face). Merus with row of small tubercles on dorsal margin; dorsolateral face with scattered small tubercles; ventral face with numerous well-spaced small tubercles. Ischium ventral face armed with small spines. Coxa with setose ventromesial margin.

Left cheliped (Fig. 12e) evenly calcified, covered with dense (ventral surfaces) to moderately dense setae (dorsal surfaces). Fingers with tips crossed when closed, terminating in small corneous claws; dorsal surfaces with small spines on proximal half; dorsal and ventral

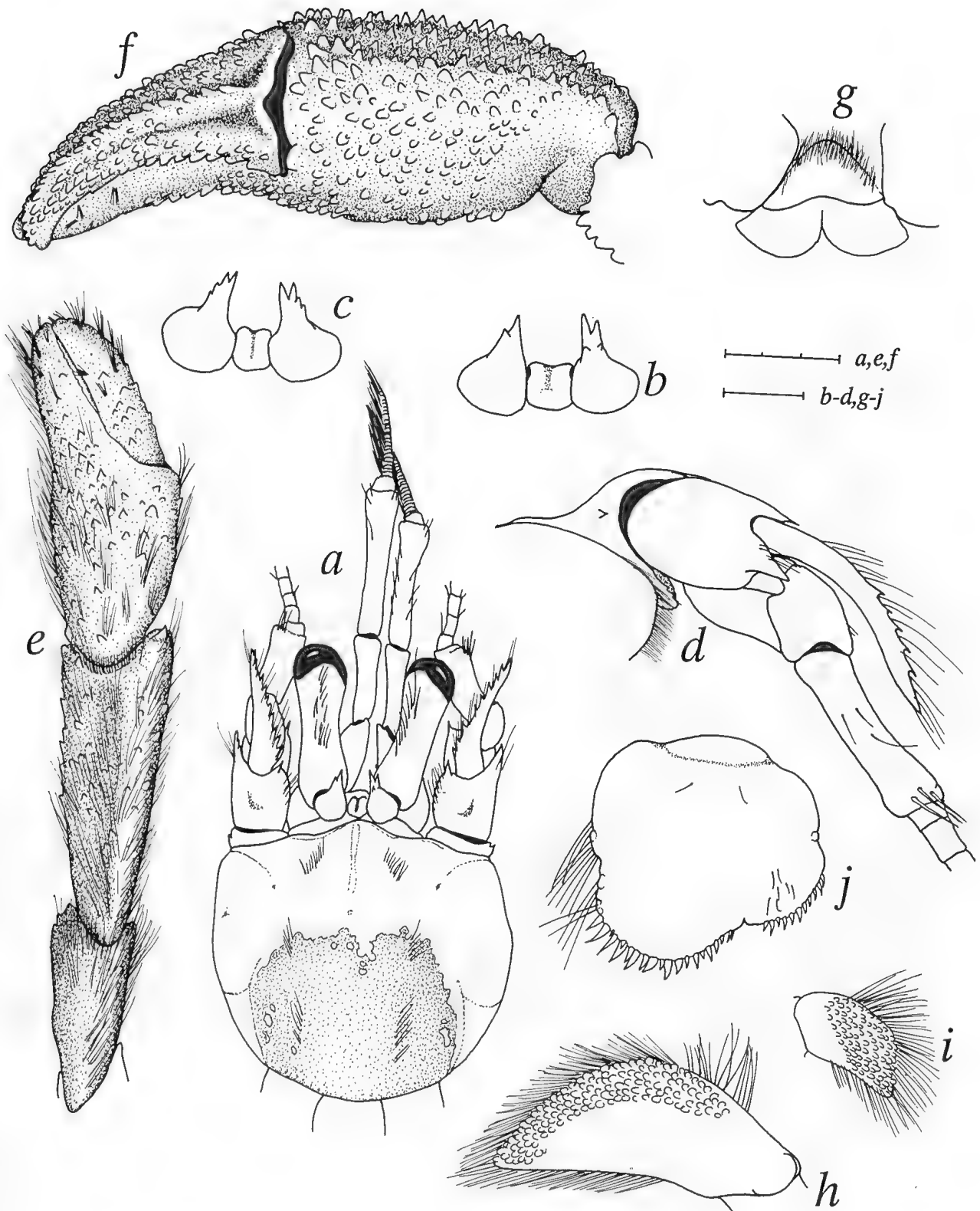


Fig. 12. *Sympagurus soela* n.sp. a, shield and cephalic appendages; b, c, ocular acicles, dorsal; d, right antennal peduncle, lateral; e, left cheliped; f, right chela, mesial (setae omitted); g, sternite of 3rd pereopods; h, i, exopod of uropods, dorsal: h, left; i, right; telson. Scales = 3 mm (a, e, f), and 1 mm (b-d, g-j). (Queensland, NTM Cr 006854: a, b, d-j, holotype male [SL 6.5 mm]; c, paratype male [SL 6.4 mm]).

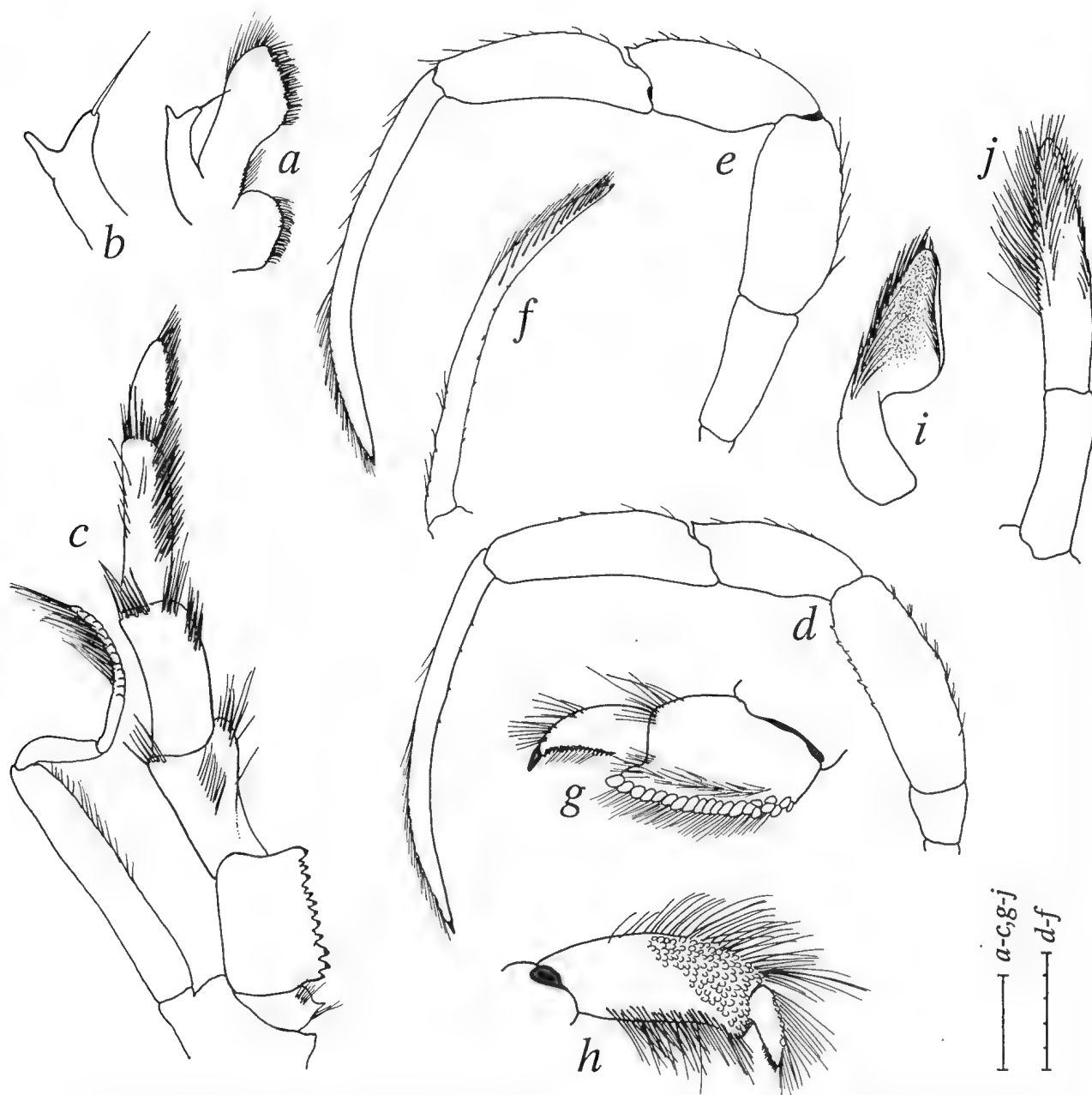


Fig. 13. *Sympagurus soela* n.sp. a, left maxillule, internal; b, endopod of same; c, left 3rd maxilliped, internal; d, left 2nd pereopod, lateral; e, left 3rd pereopod, lateral; f, dactyl of same, mesial; g, propodus and dactyl of left 4th pereopod, lateral; h, propodus and dactyl of right 5th pereopod, lateral; i, male left 1st gonopod, mesial; j, male left 2nd gonopod, anterior. Scales = 1 mm (a-c, g-j), and 5 mm (d-f). (Queensland, NTM Cr 006854: a-c, i, j, paratype male [SL 6.4 mm]; d-h, holotype male [SL 6.5 mm]).

surfaces with scattered tufts of setae. Dactyl subequal in length to palm; cutting edge with row of small, fused corneous spinules. Fixed finger with cutting edge with evenly-sized, small calcareous teeth and overlapping row of fused corneous spinules. Palm with numerous spines on dorsal surface. Carpus with small dorsodistal spine, and small spine at laterodistal angle; dorsolateral face with scattered small, blunt spines; dorsal margin with row of 3 or 4 small spines. Merus and ischium unarmed. Coxa with setose ventromesial margin.

Ambulatory legs (Fig. 13d-f) similar from right to left, long, reaching or exceeding tips of fingers of extended right cheliped. Dactyl long, about twice as long as propodus, terminating in sharp corneous claw; ventral margin armed with row of 7 to 11 small corneous spines; with dorsodistal and dorsomesial row of long setae. Propodi with short setae on dorsal margin. Carpus with small dorsodistal spine, and row of short setae dorsally. Merus with row of short setae dorsally and occasionally with row of small spines in specimens SL < 5.0 mm;

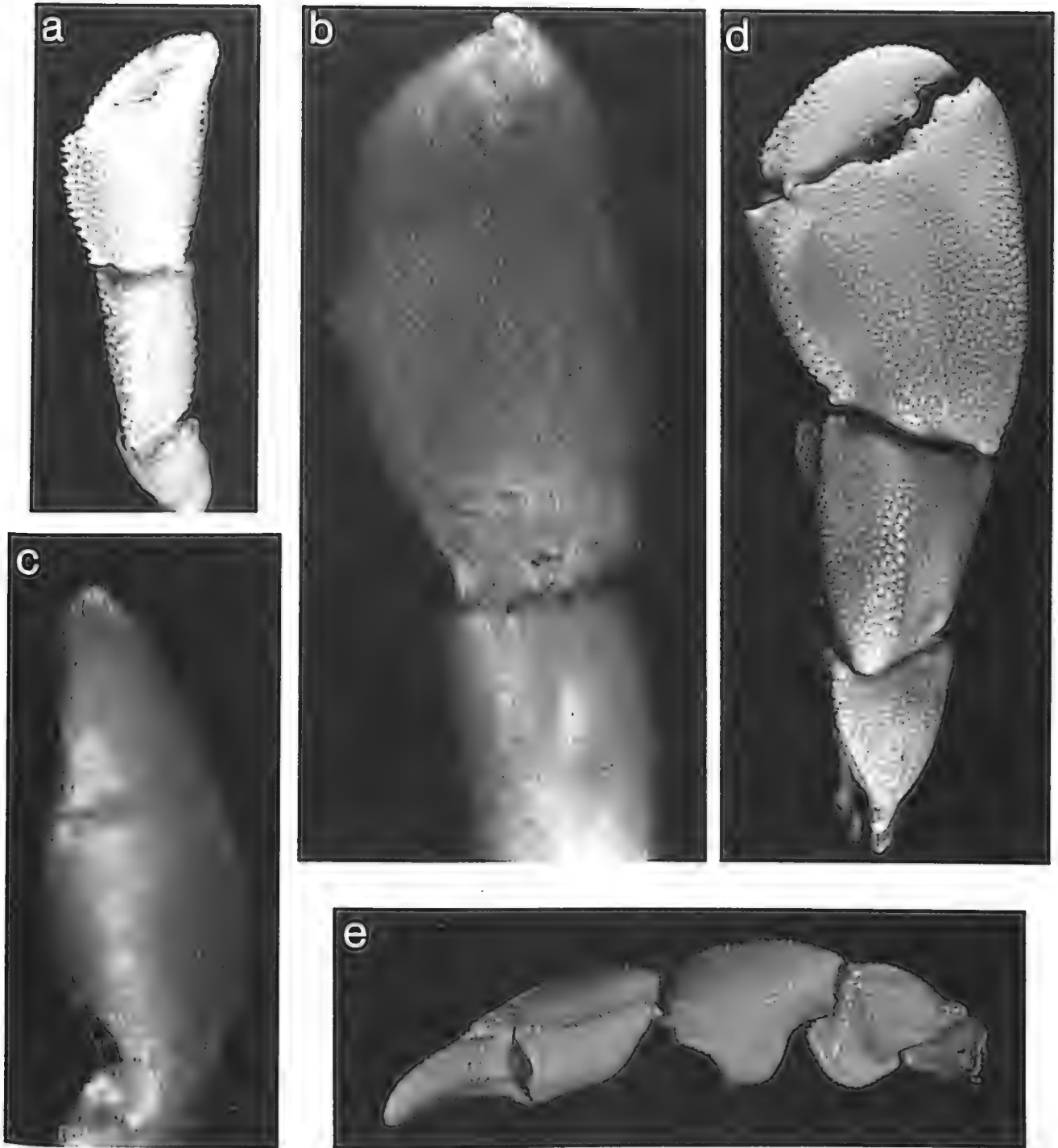


Fig. 14. Right chelipeds: a, *Sympagurus soela* n.sp. (2.5 $\times$ ). b,c, *S. villosus* n.sp.: b, carpus and chela, dorsal (2.8 $\times$ ); c, chela, mesial (2.5 $\times$ ). d,e, *Paragiopagurus diogenes* (Whitelegge, 1900): d, dorsal (2.7 $\times$ ); e, mesial (1.8 $\times$ ).

merus of 2nd pereopod with row of blunt to sharp tubercles on ventral margin distally, merus of 3rd pereopod unarmed. Ischium and coxa unarmed. Anterior lobe of sternite of 3rd pereopods (Fig. 12g) unarmed, setose.

Fourth pereopod (Fig. 13g) semichelate. Dactyl subtriangular, terminating in sharp corneous claw, and with ventrolateral row of small corneous spinules.

Propodus longer than broad, rasp formed of 1 row of rounded or ovate scales. Carpus and merus with dense setae on dorsal margins.

Fifth pereopod (Fig. 13h) semichelate. Propodal rasp extending to mid-length of segment.

Uropods and telson (Fig. 12h-j) asymmetrical. Telson with anterior and posterior lobes separated by weak transverse suture, dorsal surface with scattered setae;



posterior lobes separated by V-shaped cleft, terminal margins of lobes armed with strong corneous spines.

Males with paired 1st and 2nd gonopods well developed. First gonopods (Fig. 13i) each with concave distal lobe. Second gonopods (Fig. 13j) each with distal segment nearly flat, setose on lateral and mesial margins and on distal portion of anterior face. Female with vestigial 2nd right pleopod.

**Habitat and symbiotic associations.** Gastropod shells.

**Distribution.** So far known only from Australia. Depth: 274 to 704 m.

**Etymology.** The specific name is for the FRV *Soela*, in recognition of the collecting efforts conducted on this ship.

**Affinities.** This species is most similar to *Sympagurus affinis* (Henderson, 1888). The two can be separated by the armature of the dorsal surface of the right and left chelae. In *S. soela* both chelae have numerous spines on the dorsal surface (Fig. 12e,f, 14a), whereas in *S. affinis* the chelae are unarmed dorsally.

**Remarks.** In a study of parapagurids from French Polynesia, Lemaitre (1994: 381) mentioned that he had examined specimens of *S. affinis* from Australia. Further study of those specimens has shown that they actually represent the new species *S. soela*. Although *S. affinis* is broadly distributed in the central and western Pacific (Indonesia, Philippines, Hawaiian Islands, and French Polynesia), so far it has not been found in Australian waters.

### *Sympagurus trispinosus* (Balss, 1911)

*Parapagurus arcuatus* var. *trispinosa* Balss, 1911: 3 (type locality: Tiefsee-Exped. "Valdivia", Pemba Canal [western Indian Ocean], sta. 246, 05°24'S, 39°19'E, 818 m).—Balss, 1912: 100, fig. 8, pl. 7, fig. 2, pl. 10, fig. 4.

*Parapagurus trispinosus*.—De Saint Laurent, 1972: 105.

*Sympagurus trispinosus*.—Lemaitre, 1989: 37; 1994: 390, figs 11, 12, 28e.

**Type material.** SYNTYPES: 3 females, Zoologische Staatssammlung, Munich (presumably lost, L. Tiefenbacher, pers. comm.).

**Australian material.** QUEENSLAND: 9 males (SL 8.5–19.0 mm), 1 female (SL 7.5 mm), 4 females ovig. (SL 10.5–19.0 mm), off Cairns, 16°55'S, 151°34'E, trawled, FRV *Soela*, cruise 6, sta. 78, 880 m, 6 Dec 1985, coll. P.J.F. Davie, QM W16514. 1 male (SL 16.1 mm), 1 female ovig. (SL 9.0 mm), off Cairns, 17°01'S, 151°20'E, P.J.F. Davie, FRV *Soela*, cruise 6, sta. 79, 800 m, 6 Dec 1985, QM W16513. 1 female ovig. (SL 14.0 mm), off Tully, CIDARIS I, sta. 49–3, 17°52'S, 147°10'E, trawled, ORV *Franklin*, 881–920 m, 17 May 1986, coll. JCU, QM W16497. 1 male (SL 20.5 mm), off Tully, CIDARIS I, sta. 48–3, 17°52'S, 147°08'E, trawled, ORV *Franklin*, 700 m, 17 May 1986, coll. JCU, QM W16502. 1 female (SL 9.4 mm), 1 female ovig. (SL 11.0 mm), off Tully, CIDARIS I, sta. 50–3, 18°02'S, 147°20'E, trawled, ORV *Franklin*, 918–891 m, 17 May 1986, coll. JCU, QM W16499.

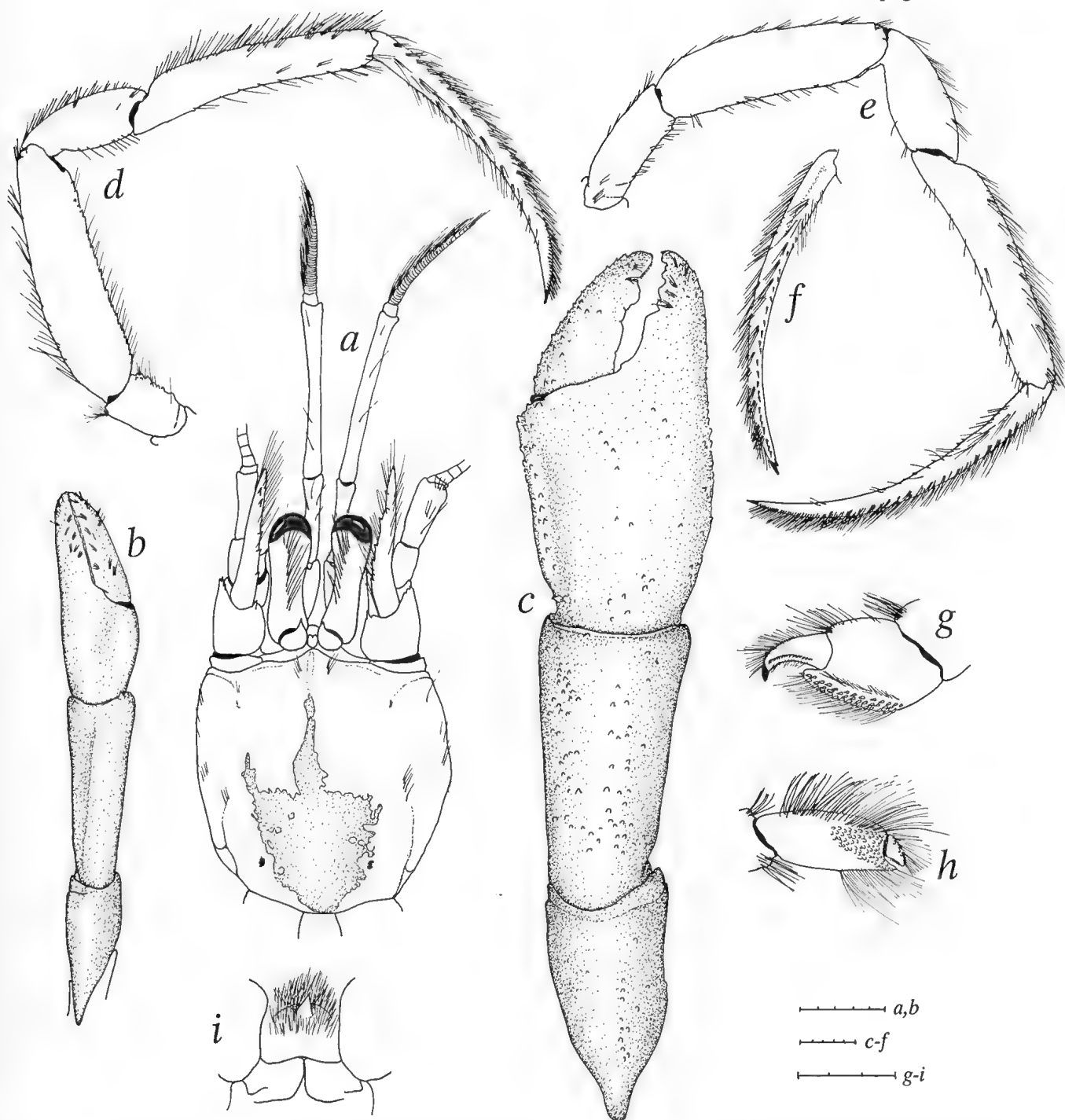
1 male (SL 11.4 mm), Marion Plateau, FRV *Soela*, sta. 0685–35, 19°00.65'S, 150°39.2'E, 752–751 m, 24 Nov 1985, NTM Cr 006840. 1 male (SL 15.8 mm), Marion Plateau, FRV *Soela*, sta. 0685–09, 22°57'S, 154°25.5'E, 678–695 m, 18 Nov 1985, NTM Cr 006853. 1 female (SL 14.7 mm), Southern Intruder Survey, shot 40, 23°17'S, 153°56'E, 460 m, 30 Nov 1983, coll. P.J.F. Davie, QM W11304.

**Diagnosis.** First 11 pairs of gills intermediate. Shield as long as broad; dorsal surface weakly calcified medially; rostrum broadly rounded, with low dorsal ridge; anterior margins straight; lateral projections broadly subtriangular, terminating acutely or bluntly; posterior margin broadly rounded. Ocular peduncles half or slightly more than length of shield; ocular acicles subtriangular, terminating in bifid or multifid spine; corneae slightly dilated. Sternite of third maxillipeds with small spine on each side of midline. Epistomial spine short, straight. Antennular peduncle exceeding distal margin of corneae by about 0.3 length of penultimate segment. Antennal peduncle exceeding distal margin of cornea by about 0.5 length of fifth segment; 4th segment unarmed; 3rd segment with strong ventromesial distal spine (occasionally bifid); acicles slightly exceeding distal margin of corneae, mesial margin armed with 9 to 13 small spines; flagellum long, naked. Chelipeds dissimilar, with dense setae obscuring surfaces. Right cheliped with chela less than twice as long as wide, dorsal and ventral faces smooth; palm with mesial and lateral faces rounded or with dorsolateral margin weakly delimited by irregular rows of small spines; carpus with numerous small tubercles or spines on proximal half of dorsal surface. Left cheliped evenly calcified, chela unarmed; carpus unarmed or with irregular row of tubercles or spines on dorsal margin. Ambulatory legs long, slender, reaching to tip of extended right cheliped; dactyl about 1.7 times as long as propodus, with row of about 18 corneous spines on ventromesial margin, and with several short, oblique rows of bristles on mesial face distally; carpus with small dorsodistal spine; ischium and merus of 2nd pereopod each with row of small often obsolete spines on ventral margin. Anterior lobe of sternite of third pereopods unarmed, or with 1 marginal spine. Fourth pereopod with propodal rasp consisting of 3 to 4 irregular rows of conical scales. Uropods and telson markedly asymmetrical; telson with anterior lobes each with fringe of long setae on ventrolateral margin; posterior lobes separated by broad, shallow median cleft, terminal margins armed with numerous corneous spines. Male 1st gonopods each with ovate, weakly concave distal lobe; second gonopods each with distal segment nearly flat. Females with 2nd left pleopod with rami about twice as broad as rami of 3rd and 4th pleopods; with right vestigial second pleopod.

**Colour.** Body mostly cream yellow; tips of dactyls of ambulatory legs pinkish (Lemaitre, 1994).

**Distribution.** Indo Pacific: Zanzibar; South Africa; Indonesia; Australia; and French Polynesia. Depth: 460 to 1412 m.





**Fig. 15.** *Sympagurus villosus* n.sp. a, shield and cephalic appendages; b, left cheliped, denuded; c, right cheliped, denuded; d, right 2nd pereopod, lateral; e, right 3rd pereopod, lateral; f, dactyl of same, mesial; g, propodus and dactyl of left 4th pereopod, lateral; h, propodus and dactyl of left 5th pereopod, lateral; i, sternite of 3rd pereopods; Scales = 5 mm (a,b,c-f), and 3 mm (g-i). (Queensland: a,d-i, holotype male [SL 13.8 mm], NTM Cr 010912; b,c, paratype male [SL 13.7 mm], QM W16516).

***Sympagurus villosus* n.sp.**

Figs 14b,c, 15, 16

**Holotype.** 1 male (SL 13.8 mm), Marion Plateau, Queensland, FRV *Soela*, sta. 0685-09, 22°57'S, 154°25.5'E, 678-695 m, 18 Nov 1985, NTM Cr 010912.

**Paratypes.** QUEENSLAND: 1 female (SL 7.2 mm), same sta. data as holotype, NTM Cr 010912 1 male (SL 13.7 mm), off S Stradbroke Is., MV *Iron Summer*, 27°54'S, 153°58'E, trawled, 490 m, 30 Nov 1982, coll. S. Hyland, QM W16516.

**Description.** First 11 pairs of gills intermediate. Shield

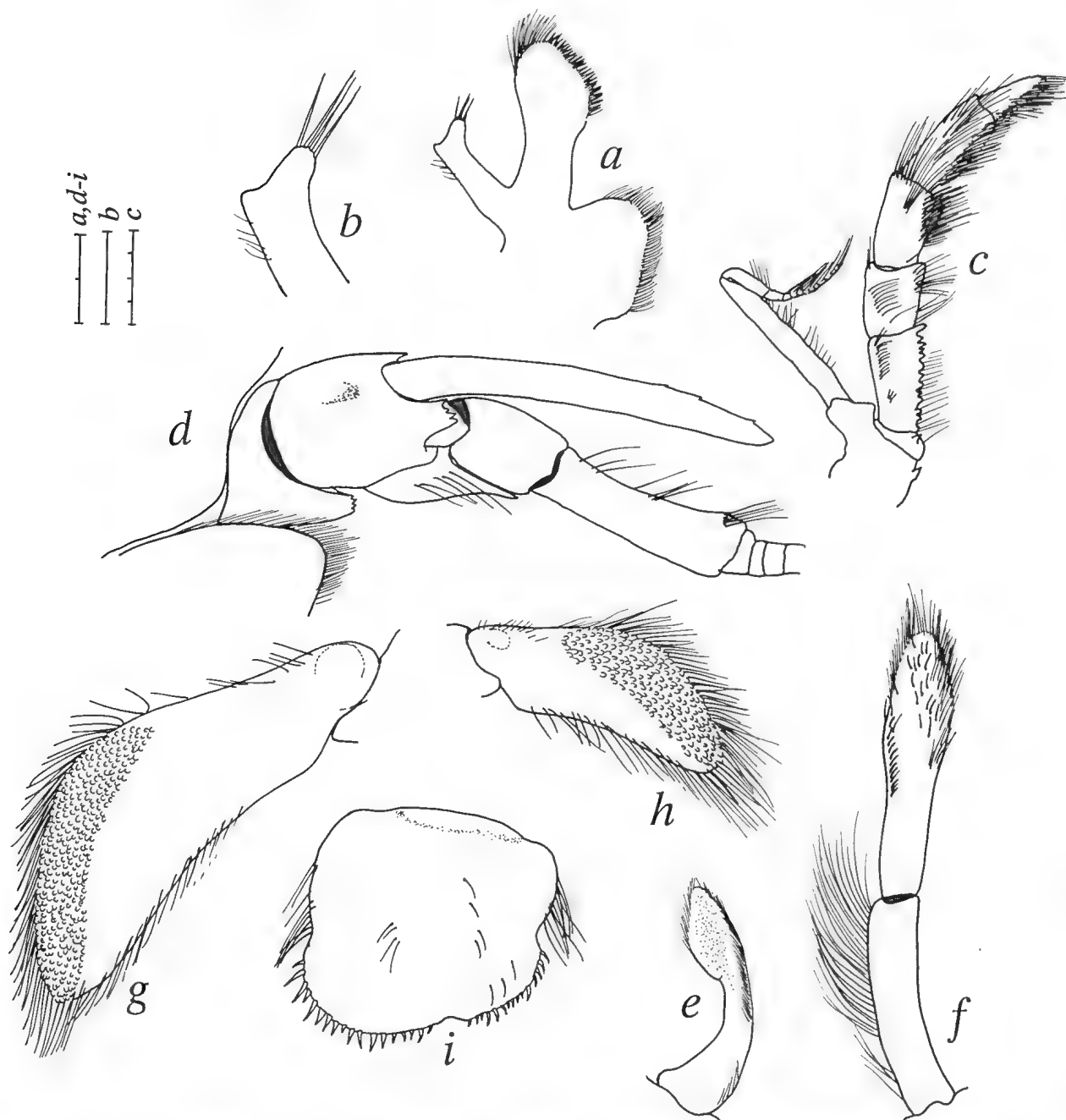


Fig. 16. *Sympagurus villosus* n.sp. a, maxillule, internal; b, endopod of same; c, left 3rd maxilliped, internal; d, right antennal peduncle, lateral; e, left male 1st gonopod, mesial; f, left male 2nd gonopod, anterior; g, h, exopod of uropods, dorsal: g, left; h, right; i, telson. Scales = 2 mm (a, d-i), 1 mm (b), and 4 mm (c). (Queensland: a-c, paratype male [SL 13.7 mm], QM W16516; d-i, holotype male [SL 13.8 mm], NTM Cr 010912).

(Fig. 15a) approximately as broad as long; dorsal surface weakly calcified, with scattered short setae; rostrum broadly triangular, with short mid-dorsal ridge; anterior margins sinuose; lateral projections broadly rounded; anterolateral margins slightly concave; posterior margin broadly rounded. Anterodistal margin of branchiostegite rounded, unarmed, setose.

Ocular peduncles about half length of shield, with row of setae dorsally. Cornea slightly dilated. Ocular acicles subtriangular, terminating in strong spine; separated

basally by less than basal width of 1 acicle.

Antennular peduncle long, slender, exceeding distal margin of cornea by half length of penultimate segment. Ultimate segment about twice as long as penultimate segment, with scattered setae. Basal segment with strong ventromesial spine; lateral face with distal subrectangular lobe armed or with 2 to 5 small spines, and strong spine proximally. Ventral flagellum with 7 to 9 articles.

Antennal peduncle (Fig. 16d) exceeding distal margin of cornea by about half length of 5th segment. Fifth

segment unarmed, with few setae on lateral and mesial margins. Fourth segment unarmed. Third segment with strong ventromesial distal spine. Second segment with dorsolateral distal angle produced, terminating in multifid spine; mesial margin with spine on dorsodistal angle. First segment unarmed or with 1 or 2 small spines on lateral face; ventromesial angle produced, with 5 or 6 small spines laterally. Antennal acicles slightly curved outward (in dorsal view), exceeding distal margin of corneae by 0.3 to 0.5 length of acicle, terminating in strong spine; mesial margin armed with row 6 to 10 spines, densely setose. Flagellum long, exceeding extended right cheliped and ambulatory legs, articles with scattered setae < 1 to 2 articles in length.

Mandible with 3-segmented palp. Maxillule (Fig. 16a,b) with external lobe of endopod weakly developed, internal lobe with 4 long setae. Maxilla with endopod slightly exceeding distal margin of scaphognathite. First maxilliped with endopod slightly exceeding exopod in distal extension. Second maxilliped without distinguishing characters. Third maxilliped (Fig. 16c) with crista dentata of 14 corneous-tipped teeth; coxa and basis each with small mesial tooth. Sternite of 3rd maxillipeds with spine on each side of midline. Epistomial spine straight. Labral spine present.

Chelipeds markedly dissimilar; mesial and ventral surfaces of meri, and all surfaces on carpi and chelae, covered with dense mat of short plumose setae mixed with long simple, bristle-like setae. Right cheliped (Fig. 14b,c, 15c) with fingers nearly straight, terminating in small corneous claw; cutting edges each with irregularly-sized calcareous teeth; dorsal and ventral faces each with distal row of 3 or 4 tufts of setae parallel to cutting edge. Dactyl subequal in length to palm, set at weakly oblique angle to longitudinal axis of palm; mesial face rounded, armed with small, blunt and sharp spines; dorsal and ventral faces unarmed or with scattered small spines. Fixed finger broad at base, dorsal and ventral surfaces similar to dactyl. Palm slightly longer than broad (males) or as long as broad (females), lateral and mesial faces rounded, with irregular rows of small blunt to sharp spines; dorsal surface covered with scattered small spines; ventral surface with scattered small tubercles. Carpus with moderately dense spines or tubercles on dorsal and ventral surfaces; dorsodistal margin unarmed or with 1 or 2 small spines. Merus with scattered small tubercles on lateral face; ventromesial margin with row of small spines. Coxa and ischium each with row of small spines on ventral face; coxa with ventromesial row of setae.

Left cheliped (Fig. 15b) well calcified. Fingers terminating in small corneous claws; dorsal and ventral surfaces unarmed but with several tufts of setae; cutting edge of dactyl with row of minute, fused corneous teeth; cutting edge of fixed finger with row of regularly-spaced, small, evenly-sized teeth. Dactyl longer than palm in length. Palm unarmed on all surfaces. Carpus unarmed except for small dorsodistal spine. Merus unarmed. Ischium with row of small spines on ventral margin. Coxa unarmed but with ventromesial row of setae.

Ambulatory legs (Fig. 15d-f) generally similar from right to left (or right with slightly longer segments than left), at most exceeding extended right cheliped by about 0.5 length of dactyl; meri, carpi, propodi, and dactyls with numerous stiff setae (more numerous on dactyl). Dactyl approximately 1.4 times as long as propodus, terminating in sharp corneous claw; with dorsal and dorsomesial row of long setae (setae arranged in tufts on proximal two-thirds), and ventromesial row of about 32 corneous spines (most clearly visible in mesial view). Propodus with setae on dorsal and ventral margins. Carpus usually with blunt dorsodistal angle, or at most with small blunt dorsodistal spine, and row of setae dorsally. Merus with setae on dorsal and ventral margins; merus of 2nd pereopods with row of small spines on ventral margin. Ischium of 2nd pereopod with small spines on ventral margin. Coxa of 2nd pereopod with few small spines on ventrodistal margin. Anterior lobe of sternite of 3rd pereopods armed with strong marginal spine, setose (Fig. 15i).

Fourth pereopod (Fig. 15g) semichelate. Dactyl subtriangular, terminating in sharp corneous claw, and ventrolateral row of small corneous spinules. Propodus longer than broad, rasp formed of 2 or 3 irregular rows of conical scales. Merus and carpus with long setae on dorsal margin.

Fifth pereopod (Fig. 15h) semichelate. Propodal rasp extending to mid-length of segment.

Uropods and telson (Fig. 16g-i) markedly asymmetrical. Telson with weak transverse suture; posterior lobes separated by shallow cleft, terminal margin of lobes armed with weakly curved corneous spines.

Males with paired 1st and 2nd gonopods; 1st gonopods (Fig. 16e) each with moderately concave distal lobe; 2nd gonopods (Fig. 16f) each with distal segment nearly flat, anterior face setose distally, and row of short setae on lateral margin medially; basal segment with long setae on posterior face. Females with vestigial 2nd right pleopod.

**Habitat and symbiotic associations.** Found living in zoanthids (*Epizoanthus* sp.).

**Distribution.** So far known only from Australia. Depth: 490 to 695 m.

**Etymology.** The specific name is from the Latin *villosus*, hairy, in reference to the dense setation on the chelipeds and ambulatory legs of this species.

**Affinities.** This new species superficially resembles *Sympagurus trispinosus* (Balss, 1911), but differs from it in pilosity of the chelipeds and ambulatory legs, and armature of ocular acicles. The pilosity of both right and left chelipeds of *S. villosus* is very dense, consisting of a mat of short plumose setae mixed with numerous long, simple bristle-like setae (Fig. 14b,c). Pilosity of the chelipeds of *S. trispinosus* is also dense but consists

of a mat of only short plumose setae. The ocular acicles are simple on *S. villosus*, whereas they are multifid on *S. trispinosus*. Other characters helpful in distinguishing the two species include armature of the ventromesial margin of the dactyls of the ambulatory legs; the dactyl has about 32 spines on *S. villosus*, and about 18 spines on *S. trispinosus*. Also helpful is the relative length of the propodi and dactyls of the ambulatory legs; the dactyl is about 1.4 times as long as the propodus on *S. villosus*, and about 1.7 times as long as the propodus on *S. trispinosus*. Additionally, the new species lives symbiotically with a zoanthid (*Epizoanthus* sp.), whereas *S. trispinosus* lives with the actinian *Stylobates cancrisocia* (Carlgren) (see Fautin Dunn *et al.*, 1980).

### *Oncopagurus* n.gen.

*Sympagurus*.—Lemaitre, 1989: 36 (in part).

**Diagnosis.** Eleven pairs of phyllobranchiate gills. Shield about as broad as long; dorsal surface usually weakly calcified medially. Corneae weakly to moderately dilated. Fourth segment of antennal peduncle armed with dorsodistal spine. Epistomial spine strongly curved upward. Right chela operculate, with well delimited dorsomesial and dorsolateral margins. Left cheliped with

carpus and palm frequently with weakly calcified areas. Ambulatory legs with dactyls curved. Fourth pereopod with propodal rasp consisting of 1 row of corneous scales. Second abdominal somite with left pleuron terminating ventrally in small subtriangular lobe. Males with poorly to moderately developed paired 1st and 2nd gonopods; 1st sometimes absent, or if present each with weakly concave distal lobe; 2nd gonopods each with flat distal segment.

**Species.** In addition to *Oncopagurus cidaris* n.sp., the following are included in this new genus: *Sympagurus africanus* (De Saint Laurent, 1972), *S. bicristatus* (A. Milne Edwards, 1880), *S. gracilis* (Henderson, 1888), *S. haigae* (De Saint Laurent, 1972), *S. indicus* Alcock, 1905, *S. minutus* (Henderson, 1896), *S. monstrosus* (Alcock, 1894), *S. orientalis* (De Saint Laurent, 1972), and *S. tuamotu* Lemaitre, 1994.

**Type species.** *Eupagurus bicristatus* A. Milne Edwards, 1880.

**Etymology.** From the Greek *onkos* meaning hook, and *pagourus* meaning crab, and referring to the curved, hook-like epistomial spine in this genus. Gender: masculine.

### Key to Australian species of *Oncopagurus* n.gen.

1. Corneae somewhat cone-shaped (Fig. 21a,b) ..... *O. minutus*  
 — Corneae not cone-shaped ..... 2
2. Merus of right 3rd pereopod unarmed dorsally; corneal width distinctly greater than distal width of ocular peduncle ..... *O. monstrosus*  
 — Merus of right 3rd pereopod armed dorsally with small spines; corneal width subequal to distal width of ocular peduncle ..... 3
3. Male with paired 1st gonopods; female with mesial face of right palm expanded distally and with ventromesial margin well delimited by row of spines (Fig. 18a,c) ..... *O. indicus*  
 — Male lacking paired 1st gonopods; female (and male) with mesial face of right palm not expanded distally and with ventromesial margin not delimited by row of spines (Fig. 22c,d) ..... *O. cidaris* n.sp.

*Oncopagurus indicus* (Alcock, 1905)

Figs 17, 18

*Sympagurus bicristatus* var. *indicus* Alcock, 1905: 105, pl.10, fig. 4.—Gordan, 1956: 341 (type locality: Andaman Sea).  
*Parapagurus bicristatus*.—Balss, 1912: 98, figs 6, 7. (Not *Parapagurus bicristatus* [A. Milne Edwards, 1880]).  
 ?*Parapagurus minutus*.—Thompson, 1943: 417. (?Not *Parapagurus minutus* Henderson, 1896). (See remarks).  
*Sympagurus bicristatus*.—Thompson, 1943: 418.  
*Parapagurus bicristatus indicus*.—De Saint Laurent, 1972: 112.  
*Sympagurus indicus*.—Lemaitre, 1989: 37.—Lemaitre, 1994: 412.

**Type Material.** Syntypes from Andaman Sea, Indian Ocean, probably in Indian Museum, Calcutta (not seen).

**Material examined.** WESTERN AUSTRALIA: 1 male (SL 2.7 mm), 1 female ovig. (SL 2.1 mm), WSW of Lancelin, WAM 1746–86.

QUEENSLAND: 1 male (SL 2.3 mm), off Tully, CIDARIS I, sta. 43-2, 17°35'S, 146°53'E, epibenthic sledge, ORV *Franklin*, 458–500 m, 15 May 1986, coll. JCU, QM W16590. 2 females ovig. (SL 3.0, 3.3 mm), off Tully, CIDARIS I, sta. 49–2, 17°51'S, 147°10'E, epibenthic sledge, ORV *Franklin*, 904–916 m, 17 May 1986, coll. JCU, QM W16599. 17 males (SL 2.7–4.2 mm), off Tully, CIDARIS I, sta. 47–2, 17°51.8'S, 147°07.9'E, epibenthic sledge, ORV *Franklin*, 503–497 m, 16 May 1986, coll. JCU, QM W16600.

NEW SOUTH WALES: 1 male (SL 2.4 mm), 1 female ovig. (SL 2.7 mm), off Newcastle, NZOI *Tangaroa*, cruise U207, 34°11.1'S, 151°26'E, 1998 m, 5 Oct 1982, AM P44032. 1 female (SL 3.2 mm), NZOI *Tangaroa*, cruise U222, off Newcastle, 1075–1040 m, 9 Oct 1982, AM.

**Other material (all from *Albatross*).** PHILIPPINES: 1 female (SL 3.0 mm), sta. 5342, 10°56'55"N, 119°17'24"E, 26–46 m, 23 Dec 1908, USNM 168969.

INDONESIA: 1 male (SL 3.0 mm), sta. 5586, 04°06'50"N, 118°47'20"E, 635 m, 28 Sep 1909, USNM 168970. 3 males (SL 1.8–4.2 mm), sta. 5619, 00°35'N, 127°14'40"E, 796 m, 27 Nov 1909, USNM 168971. 2 males (SL 3.6, 4.2 mm), sta. 5631, 00°57'S, 127°56'E, 1480 m, 2 Feb 1909, USNM 168972.

HAWAIIAN ISLANDS: 1 male (SL 4.2 mm), sta. 3979, Oahu, SW of Bird Island, 406–708 m, 3 Jun 1902, USNM 168959. sta. 4134, Oahu, Kauai Channel, 22°03'35"N, 159°19'40"W, 593–412 m, 1 Aug 1902, USNM 168968. 2 males (SL 1.6, 2.2 mm), 1 female (SL 1.8 mm), sta. 4133, Oahu, Kauai Channel, 22°02'40"N, 159°19'55"W, 302 m, 1 Aug 1902, USNM 168967. 1 male (SL 2.7 mm), sta. 4132, Oahu, Kauai Channel, 22°01'30"N, 159°21'10"W, 470–571 m, 1 Aug 1902, USNM 168966. 2 females (SL 2.1, 2.2 mm), sta. 4131, 21°59'35"N, 159°20'40"W, 565–470 m, 1 Aug 1902, USNM 168965. 1 male (SL 3.0 mm), 1 female (SL 2.5 mm), sta. 4122, Oahu, SW of Barbers Point Light, 351–644 m, 26 Jul

1902, USNM 168964. 1 male (SL 2.8 mm), sta. 3917, Oahu, SW of Diamond Head, 604–538 m, 6 May 1902, USNM 168857. 1 female (SL 2.5 mm), sta. 3815, Oahu, SE of Diamond Head, 571–417 m, 28 Mar 1902, USNM 168952. 2 males (SL 2.7, 3.1 mm), sta. 3909, Oahu, SW of Diamond Head, 563–589 m, 5 May 1902, USNM 168956. 1 male (SL 1.6 mm), sta. 3918, Oahu, SW of Diamond Head, 538–470 m, 6 May 1902, USNM 168958. 1 male (SL 1.5 mm), 1 female (SL 1.6 mm), sta. 4095, Pailolo Channel, off Mokuhooniki Is., 21°14'30"N, 156°29'45"W, 530–523 m, 22 Jul 1902, USNM 168962. 3 males (SL 1.9–2.2 mm), sta. 3866, 21°10'40"N, 156°34'50"W, 518–519 m, 10 Apr 1902, USNM 168955. 2 males (SL 1.6, 2.8 mm), 4 females (SL 1.6–2.1 mm), sta. 4084, Maui, W of Puniawa Point, 21°06'40"N, 156°20'15"W, 463–488 m, 21 Jul 1902, USNM 168960. 1 female (SL 3.1 mm), sta. 4102, between Maui and Moloka Is., Pailolo Channel, 21°03'10"N, 156°45'20"W, 223–241 m, 23 Jul 1902, USNM 168963. 1 male (2.2 mm), 2 females (SL 1.8, 1.8 mm), sta. 4085, Maui, W of Puniawa Point, 488–518 m, 21 Jul 1902, USNM 168961. 12 males (SL 1.5–3.0 mm), 8 females (SL 1.5–2.8 mm), sta. 3839, south coast of Molokai Is., 21°02'N, 157°09'40"W, 474–487 m, 4 Apr 1902, USNM 168954. 3 males (SL 2.5–3.0 mm), 5 females (SL 1.9–2.4 mm), sta. 3836, 21°00'05"N, 157°08'20"W, 435–466 m, 3 Apr 1902, USNM 168953.

**Diagnosis.** Shield (Fig. 17a) as long as broad; rostrum broadly rounded, with low dorsal ridge; anterior margins weakly concave; lateral projections subtriangular, usually terminating in small spine; ventrolateral margin with small spine (not always visible in dorsal view); posterior margin broadly rounded. Ocular peduncles more than half length of shield; ocular acicles subtriangular, terminating in strong spine; corneae slightly dilated. Maxillule with internal lobe of endopod with long seta. Sternite of 3rd maxillipeds with small spine on each side of midline. Antennular peduncle exceeding distal margin of corneae by full length of ultimate segment. Antennal peduncle (Fig. 17b) at most reaching distal margin of cornea; 2nd segment with dorsolateral distal angle produced, terminating in strong simple or multifid spine; acicles reaching distal margin of corneae, mesial margin with 8 to 11 spines; flagellum with few setae about 1 flagellar article in length. Chelipeds markedly dissimilar, both with moderately dense setae. Right cheliped (Fig. 17d, 18a–d) exhibiting sexual dimorphism. Males with right palm varying from as long as broad to slightly longer than broad; dorsomesial margin always well delimited by row of spines, ventromesial margin varying from weakly to well delimited by row of tubercles or spines; mesial face occasionally weakly expanded distally. Females with right palm broader than long, mesial face concave and expanded distally (more so in large females SL > 3.0 mm). Left cheliped (Fig. 17c) usually weakly calcified on lateral face of carpus; dorsal margin of carpus with irregular row of small spines, or few small tubercles, or unarmed; carpus with dorsodistal spine. Ambulatory legs (Fig. 17f–h) with dactyl with row of about 4 corneous spines on ventromesial margin, and dorsal and dorsomesial rows of long setae; carpus with small dorsodistal spine; merus of 3rd pereopods (Fig. 18e,f) each with row of 2 to 8 small

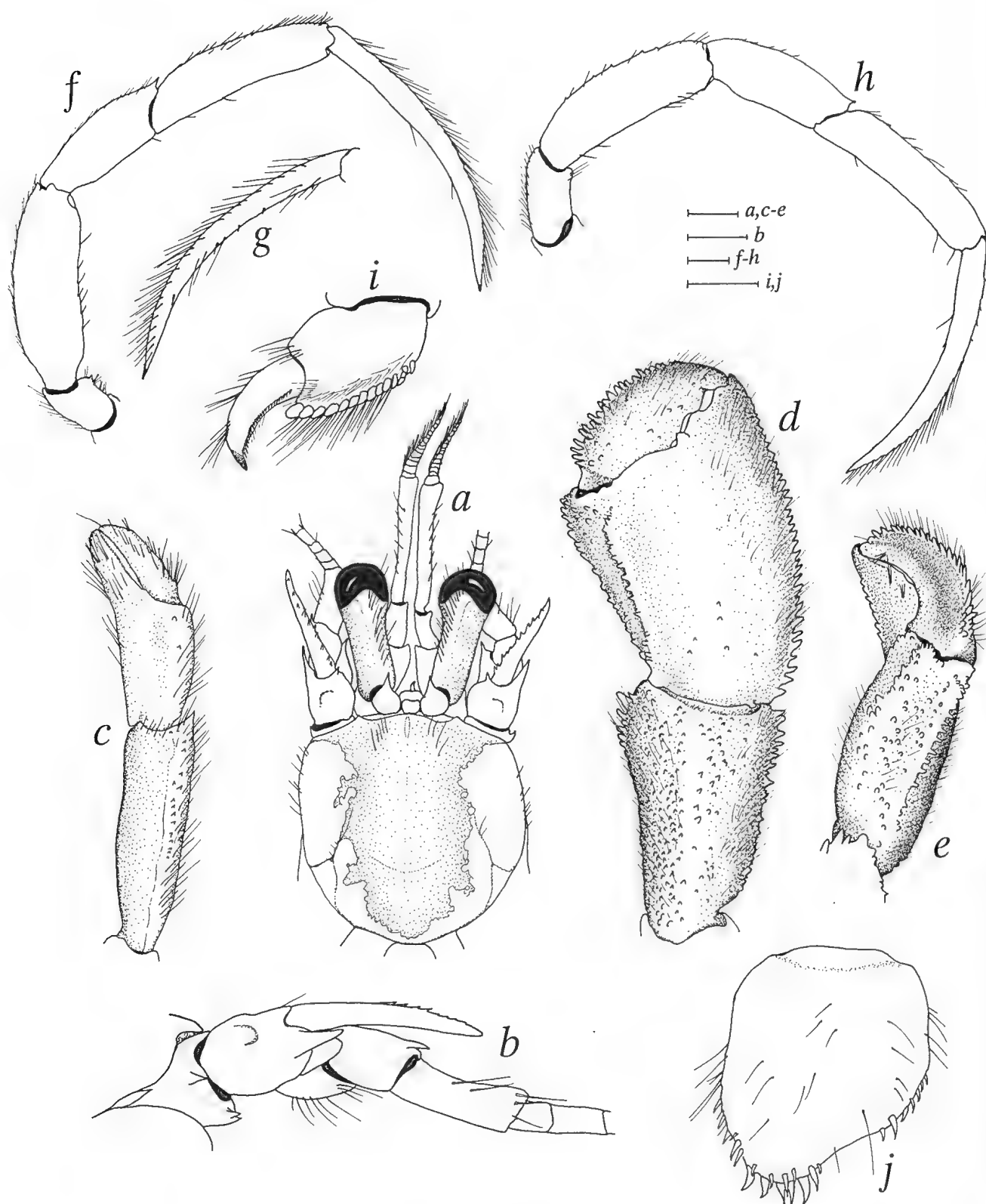
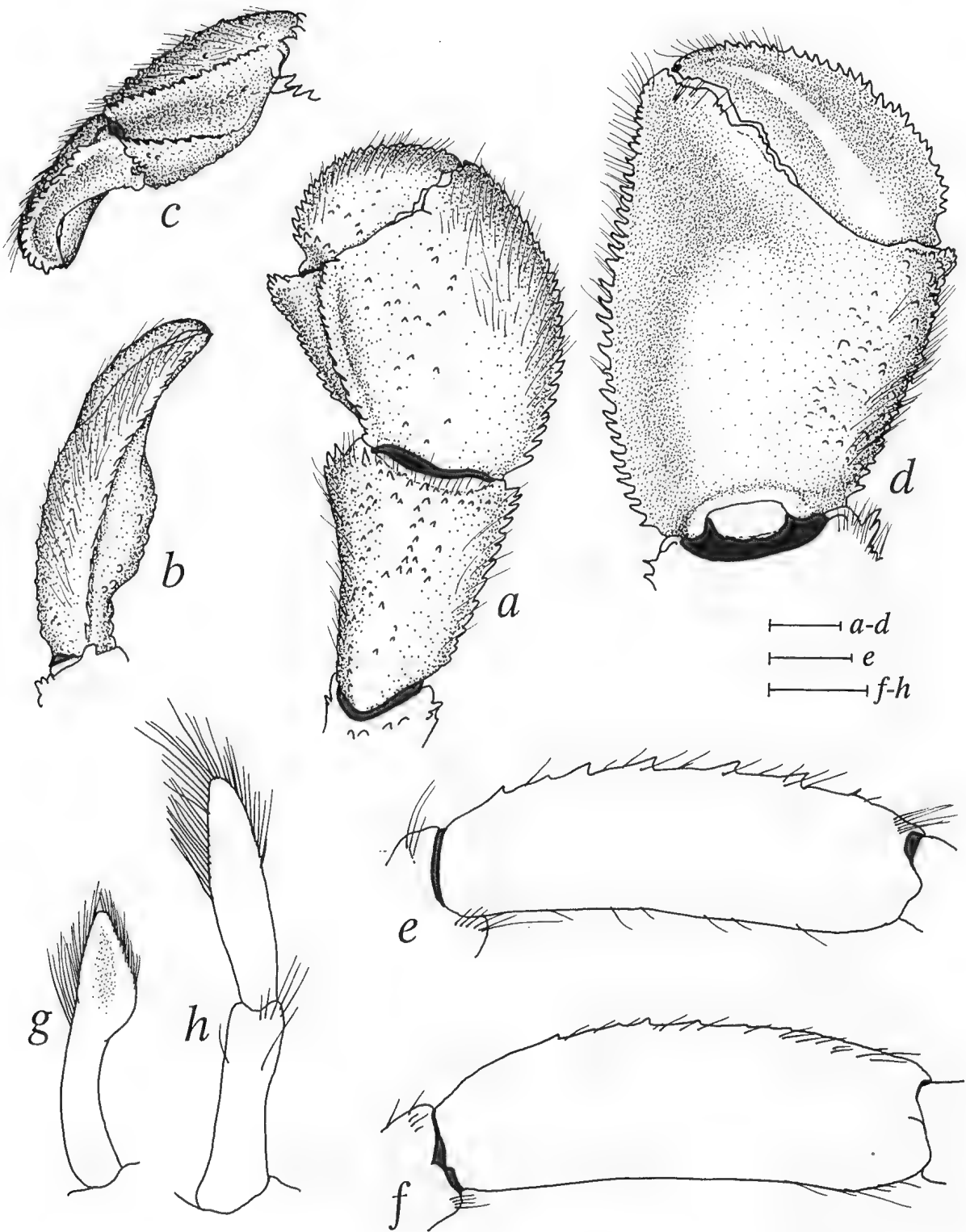


Fig. 17. *Oncopagurus indicus* (Alcock, 1905). a, shield and cephalic appendages; b, right antennal peduncle, lateral; c, carpus and chela of left cheliped; d, carpus and chela of right cheliped; e, chela of same, mesial; f, right 2nd pereopod, lateral; g, dactyl of same, mesial; h, right 3rd pereopod, lateral; i, propodus and dactyl of left 4th pereopod, lateral; j, telson. Scales = 1 mm (a,c-h), and 0.5 mm (b,i,j). (Male [SL 4.0 mm], Queensland, QM W16600).



**Fig. 18.** *Oncopagurus indicus* (Alcock, 1905). a, carpus and chela of right cheliped of female; b, chela of same, lateral; c, same, mesial; d, right chela of male, ventral; e, f, merus of right 3rd pereopods, lateral; g, male right 1st gonopod, mesial; h, male right 2nd gonopod, posterior. Scales = 1 mm (a-d, f), 0.5 mm (e), and 1 mm (g, h). (Queensland: a-c, female [SL 3.3 mm], QM W16599; d, male [3.7 mm], QM W16600; e, male [SL 2.5 mm], QM. W16600; f-h, male [SL 4.0 mm], QM W16600).



spines (occasionally with 1 spine). Anterior lobe of sternite of 3rd pereopods setose, armed with marginal spine. Fourth pereopod (Fig. 17i) with propodal rasp consisting of ovate scales. Uropods and telson (Fig. 17j) markedly asymmetrical, lacking transverse suture separating anterior and posterior lobes; posterior lobes separated by shallow U-shaped median cleft, terminal margins armed with often strongly curved corneous spines. Male 1st gonopods (Fig. 18g) each with weakly concave distal lobe; 2nd gonopods (Fig. 18h) each with distal segment nearly flat. Females with vestigial right 2nd pleopod.

**Habitat and symbiotic associations.** Inhabits gastropod shells; occasionally with one or more anthozoan polyps attached to the shell.

**Distribution.** Indo Pacific: Zanzibar; Maldives; Indonesia; Australia; Philippines; and Hawaiian Islands. Depth: 183 to 1480 m.

**Affinities.** Among the Indo Pacific species of *Oncopagurus* n.gen., *O. indicus* is most similar to *O. monstrosus* (Alcock, 1894), from which it is often difficult to separate, particularly if only male specimens are available. Females of the two species can immediately be separated by differences in the mesial face of the palm of the right cheliped. In *O. indicus*, the mesial face of the palm is expanded distally, and has a well delimited ventromesial margin that consists of a row of spines (Fig. 18a,c). The mesial face of the palm of *O. monstrosus* is not expanded distally; the ventromesial face is rounded and lacks spines (Fig. 19e,c).

In males, the mesial face of the right palm is only of limited help in separating the two species. The mesial face of *O. indicus* is at most weakly expanded distally (Fig. 17d,e); the mesial face of *O. monstrosus* is not expanded (Fig. 19c,e). The ventromesial margin of *O. indicus* exhibits a well developed row of spines, or occasionally a row of weak spines or small tubercles distally (Fig. 17e), whereas in *O. monstrosus* the ventromesial margin is unarmed (Fig. 19e). Males of both *O. indicus* and *O. monstrosus* have a dorsomesial row of spines.

Males of the two species can best be separated by using differences in the development of the ocular peduncles and corneae, and armature of the merus of the 3rd pereopod. In both males and females of *O. indicus*, the peduncles are nearly subequal in width throughout the peduncle, and the width of the corneae is subequal to the distal width of the peduncles (Fig. 17a); in *O. monstrosus*, the peduncles increase in width distally, are slightly constricted medially, and the width of the corneae is distinctly greater than that of the peduncles (Fig. 19a). Additionally, the merus of the right 3rd pereopod is armed with spines in *O. indicus* (Fig. 18e,f), whereas it is usually unarmed in *O. monstrosus* (Fig. 19f,h).

Supplemental characters that can help to differentiate the two species of either sex are the armature of the ventral surface of the right chela, and size of the

individuals. The ventral surface of the right chela in *O. indicus* is usually smooth or at most is armed with scattered small tubercles (Fig. 18d); the ventral surface in *O. monstrosus* frequently has strong spines or tubercles (Fig. 20c,d). Individuals of *O. indicus* do not grow as large as those of *O. monstrosus*, the former rarely exceeding a SL of 3 mm (largest specimen measured is 4.0 mm), whereas the latter can reach a SL of 6.0 mm.

*Oncopagurus indicus* also resembles two Atlantic species, *O. bicristatus* (A. Milne Edwards, 1880), and *O. gracilis* (Henderson, 1888). In the absence of distributional data, *O. indicus* can be separated from the two Atlantic species by differences in the shape and armature of the right chela, antennal acicles, and 1st gonopods in males (see Lemaitre, 1989). It is of interest to note the sexually dimorphic differences of the right chela between *O. indicus* and *O. bicristatus*. In *O. indicus*, the distal expansion of the mesial face of the chela is more distinctly developed in females than in males, whereas the reverse is true in *O. bicristatus*.

**Remarks.** The high degree of variability in proportions and armature of the right cheliped, and especially the marked differences frequently seen in this cheliped between males and females, has caused problems in defining this species. Particularly problematic has been the interpretation of the usefulness of the dorsomesial and ventromesial rows of spines (often described in the literature as "crests") on the palm of the right chela. Only after examining a large number of specimens of *O. indicus* and related forms during this study, has it been possible to elucidate the limits of morphological variations of the right cheliped, and to define useful diagnostic characters for this and other structures. To fully understand how this variation has hampered proper definition of this taxon, it is useful to summarise how carcinologists have used or interpreted characters derived from the right cheliped.

Alcock (1905) initially proposed the "variety" *indicus* for the Atlantic *Sympagurus bicristatus* (A. Milne Edwards, 1880), in order to accommodate specimens from the Indian Ocean that differed slightly from the Atlantic form. Alcock noted that in his "variety" the carpus and chela of the right cheliped were longer, the right chela less oval in shape, and the antennal acicle longer, than in the typical Atlantic form. Balss (1912), who considered *Sympagurus* Smith a synonym of *Parapagurus* Smith, subsequently reported specimens of *Parapagurus bicristatus* from the Indian Ocean, and indicated that his material contained specimens assignable to both the typical form and "variety" *indicus*; the former were characterised by a short right cheliped, the latter by a long one. Balss did observe substantial variability in the shape of the right cheliped, and in particular the development of the "upper crest" (=dorsomesial row) of spines on the chela. For example, he found both short and long types of chelipeds in males of the "variety" *indicus*, and observed that in contrast to the distinct "upper crest" of spines on the chela found in the typical form, some of his specimens had only a rudimentary "upper crest". Thompson (1943) again reported specimens of *Sympagurus bicristatus* from the Indian Ocean, and

made observations similar to those of Balss (1912). Thompson (1943) was unable to assign his specimens to either the typical form or the "variety" *indicus*, because of the great variability and overlap of characters he encountered. Although Thompson suggested the possibility that A. Milne Edwards's *S. bicristatus* could be divided into as many as three species, he did not formally take that action. It was De Saint Laurent (1972) who divided, although only provisionally, this taxon into three subspecies which she placed in *Parapagurus* Smith: *P. bicristatus bicristatus*, *P. b. gracilis* Henderson, 1888, and *P. b. indicus*. Lemaitre (1989) reevaluated the characters used to define these subspecies and returned them to their original specific status. In so doing, he placed all three species in *Sympagurus*, and showed that *S. bicristatus* and *S. gracilis* occurred only in the Atlantic, whereas *S. indicus* is broadly distributed in the Indo Pacific. These three species are herein placed in the new genus *Oncopagurus*.

De Saint Laurent (1972) synonymised, without comment, the taxon that Thompson (1943) reported as *Parapagurus minutus* Henderson, 1896, with *P. bicristatus indicus*. It has not been possible to examine Thompson's material, and he did not supply sufficient information in order to confirm the assignment of his specimens to *Oncopagurus indicus*.

### *Oncopagurus monstrosus* (Alcock, 1894)

Figs 19, 20

"*Parapagurus monstrosus*" Alcock, 1894: 243 (type locality, by lectotype designation: Bay of Bengal).

*Sympagurus monstrosus*.—Henderson, 1896: 533.—Alcock & Anderson, 1897, pl. 32, fig. 4.—Alcock, 1901: 223.—Lemaitre, 1989: 37.—Lemaitre, 1994: 412.

*Sympagurus arcuatus* var. *monstrosus*.—Alcock, 1905: 104, pl. 10, fig. 5.—Gordan, 1956: 341.—Kemp & Sewell, 1912: 26.

?*Eupagurus brevimanus*.—Yokoya, 1933: 90, fig. 34. (See remarks)

*Parapagurus monstrosus*.—Miyake, 1978: 72 (key); 1982: 119, pl. 40, fig. 1.—Baba *et al.*, 1986: 302, fig. 146.—Imafuku, 1992: 234, unnumbered fig.

not *Parapagurus arcuatus* var. *monstrosus*.—Balss, 1912: 99, pl. 10, fig. 3. (= *Sympagurus brevipes* [De Saint Laurent, 1972]).

**Type material.** LECTOTYPE (herein selected): male (SL 4.2 mm), Indian Ocean, Bay of Bengal, [probably from HM Indian Marine Survey Steamer *Investigator*, sta. 120, 15°56'50"N, 81°30'30"E, 439 m, 24 Dec 1890], USNM 156566. PARALECTOTYPES: 2 males (SL 3.4, 3.7 mm), same sta. data as lectotype, USNM 156566.

**Australian material.** WESTERN AUSTRALIA: 15 males (SL 3.6–5.1 mm), 2 females (SL 3.9, 4.6 mm), 3 females ovig. (SL 4.2–4.8 mm), NW of Augustus Is., FRV *Soela*, sta. 01/84/079, 13°17'S, 122°37.4'E, 494–484 m, 15 Feb 1984, WAM 1321–86. 1 male (SL 5.0 mm), NW of Augustus Is., FRV *Soela*, sta. 01/84/078, 13°27.6'S, 122°44.4'E, 444–440 m, coll.

S. Slack-Smith, WAM 1238–86. 4 males (SL 4.9–5.2 mm), NW of Collier Bay, FRV *Soela*, sta. 01/84/070, 13°44'S, 122°13.3'E, 496–494 m, 13 Feb 1984, coll. S. Slack-Smith, WAM. 1 male (SL 5.2 mm), NW of Cape Leveque, FRV *Soela*, sta. S01/84/063, 14°43.1'S, 121°33.1'E, 410–408 m, 12 Feb 1984, WAM 1090–86. 20 males (SL 3.7–5.3 mm), NW of Beagle Bay, FRV *Soela*, sta. 01/84/060, 15°08.6'S, 121°03.4'E, 500–504 m, 11 Feb 1984, coll. S. Slack-Smith, WAM 1079–86, 1084–86. 2 males (SL 5.5, 6.0 mm), NW of Beagle Bay, FRV *Soela*, sta. 01/84/058, 15°12.8'S, 121°05.9'E, 410–404 m, 11 Feb 1984, coll. S. Slack-Smith, WAM 1078–86, 1134–86. 2 males (SL 5.7, 6.0 mm), North West Shelf, FRV *Soela*, sta. NWS-7, 18°33.2'S, 117°30.9'E, 392–400 m, 25 Apr 1983, NTM Cr 010913. 1 male (SL 6.6 mm), 1 female (SL 5.8 mm), North West Shelf, FRV *Soela*, CSIRO cruise 0184, sta. 22, 18°34.4'S, 117°30'E, 202 m, 1 Feb 1984, NTM Cr 000665, 000667. 2 males (SL 4.5, 5.2 mm), North West Shelf, FRV *Soela*, sta. 0184/16, 18°37.4'S, 117°02.4'E, 504–508 m, 31 Jan 1984, NTM Cr 011546.

**Other material (all from *Albatross*).** PHILIPPINES: 2 males (SL 4.2, 4.5 mm), sta. 5268, Verde Is., 13°42'N, 120°57'15"E, 311 m, 8 Jun 1908, USNM 168923. 1 female ovig. (SL 3.7 mm), sta. 5123, Mindoro Is., 13°12'45"N, 121°38'45"E, 518 m, 2 Feb 1908, USNM 168920. 1 female ovig. (SL 3.4 mm), sta. 5124, Mindoro Is., 12°52'N, 121°48'20"E, 514 m, 2 Feb 1908, USNM 168921. 2 males (SL 3.7, 4.5 mm), sta. 5214, Masbate Is., 12°25'18"N, 123°37'15"E, 399 m, 21 Apr 1908, USNM 168922. 2 males (3.3, 4.3 mm), 3 females (SL 2.5–2.8 mm), 1 female ovig. (SL 2.8 mm), sta. 5402, between Leyte and Cebu, 11°11'45"N, 124°15'45"E, 344 m, 16 Mar 1909, USNM 168924, 168925. 2 males (SL 3.1–3.2 mm), sta. 5404, Leyte, Dupon Bay, 10°50'N, 124°26'18"E, 347 m, 17 Mar 1909, USNM 168927. 1 male (SL 5.2 mm), sta. 5405, Leyte, Dupon Bay, 10°49'20"N, 124°24'23"E, 479 m, 17 Mar 1909, USNM 168928. 1 male (SL 2.4 mm), sta. 5535, between Cebu and Siquijor Is., 09°20'30"N, 123°23'45"E, 567 m, 19 Aug 1909, USNM 168935. 1 male (SL 4.8 mm), sta. 5541, N of Mindanao, 08°49'38"N, 123°34'30"E, 401 m, 20 Aug 1909, USNM 168936. 1 male (SL 5.1 mm), sta. 5517, N of Mindanao, 08°45'30"N, 123°33'45"E, 309 m, 9 Aug 1909, USNM 168934. 6 males (SL 3.1–4.8 mm), sta. 5506, N of Mindanao, 08°40'N, 124°31'45"E, 479 m, 5 Aug 1909, USNM 168932. 3 males (SL 3.9–5.1 mm), 1 female (SL 5.2 mm), sta. 5501, N of Mindanao, 08°37'37"N, 124°35'E, 391 m, 4 Aug 1909, USNM 168929. 1 male (SL 4.5 mm), 2 sex indet. (SL 3.6, 5.1 mm), sta. 5502, N of Mindanao, 08°37'37"N, 124°35'E, 391 m, 4 Aug 1909, USNM 168930. 4 females (SL 3.7–5.2 mm), sta. 5504, N of Mindanao, 08°35'30"N, 124°36'E, 366 m, 5 Aug 1909, USNM 168931. 1 male (SL 4.3 mm), 3 females (SL 3.7–4.9 mm), sta. 5508, N of Mindanao, Iligan Bay, 08°17'24"N, 124°11'42"E, 494 m, 5 Aug 1909, USNM 168933. 1 male (SL 3.4 mm), sta. 5550, Sulu Sea, Jolo Is., 06°02'N, 120°44'40"E, 472 m, 17 Sep 1909, USNM 168937. 1 female (SL 4.3 mm), sta. 5551, Sulu Sea, Jolo Is., 05°54'48"N, 120°44'24"E, 353 m, 17 Sep 1909, USNM 168938.

INDONESIA: 4 males (SL 3.6–4.0 mm), 1 female (SL 3.3 mm), 1 female ovig. (SL 3.4 mm), sta. 5590, Borneo, Sibuko Bay, off Mabul Is., 04°10'50"N, 118°39'35"E, 567 m, 29 Sep 1909, USNM 168939. 1 male (SL 4.2 mm), 1 female (SL 2.7 mm), sta. 5622, Moluccas, off Makyan Is., 00°19'20"N, 127°28'30"E, 503 m, 29 Nov 1909, USNM 168940. 1 male (SL 4.8 mm), 1 female (SL 2.8 mm), 00°12'15"N, 127°29'30"E, 527 m, 29 Nov 1909, USNM 168941.

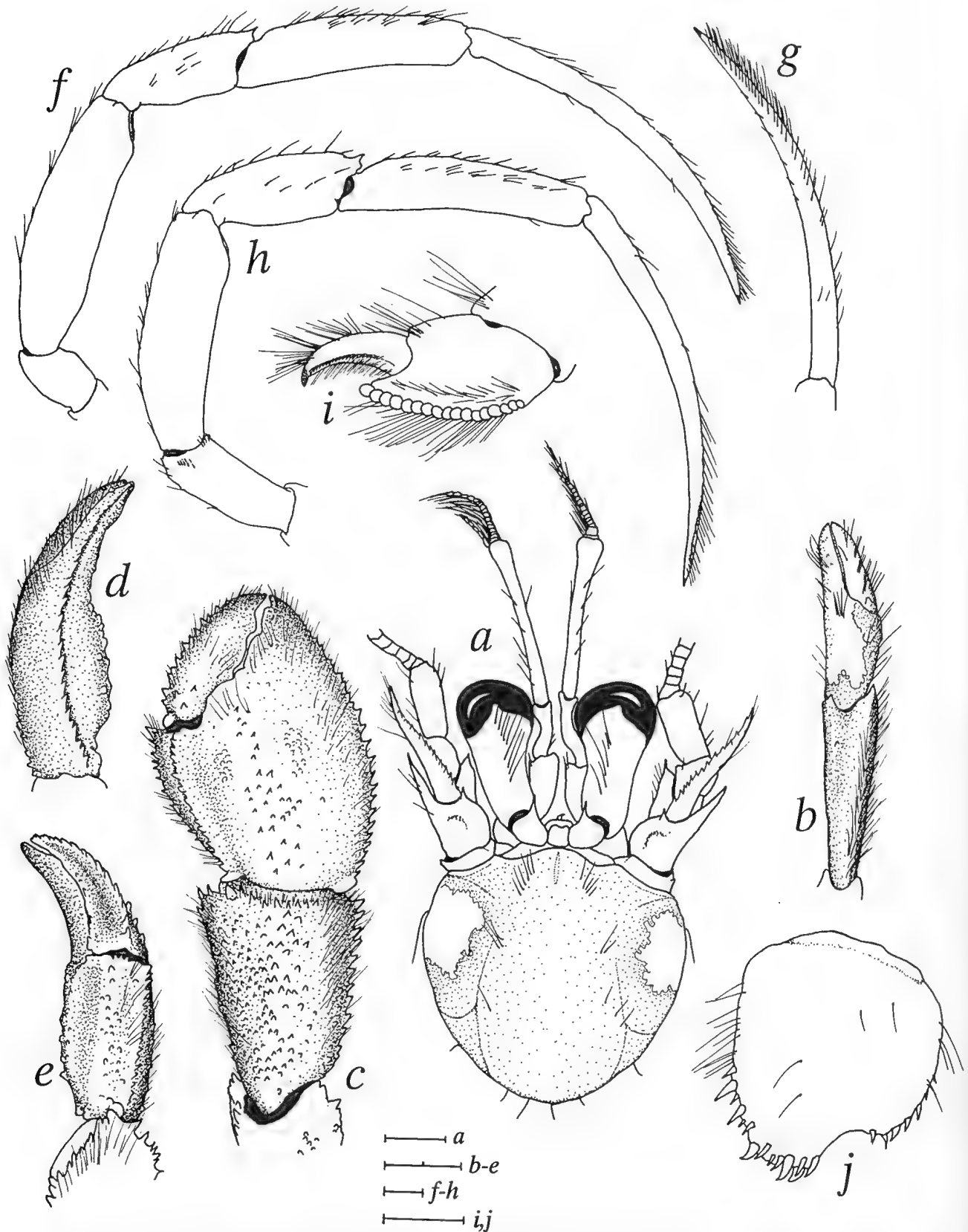


Fig. 19. *Oncopagurus monstrosus* (Alcock, 1894). a, shield and cephalic appendages; b, carpus and chela of left cheliped; c, carpus and chela of right cheliped; d, chela of same, lateral; e, same, mesial; f, right 2nd pereopod, lateral; g, dactyl of same, mesial; h, right 3rd pereopod, lateral; i, propodus and dactyl of left 4th pereopod; j, telson. Scales = 1 mm (a), 2 mm (b-e), 1 mm (f-h), 0.5 mm (i,j). (lectotype male [SL 4.2 mm], Bay of Bengal, USNM 156566).

**Diagnosis.** Shield (Fig. 19a) as long as broad; dorsal surface weakly calcified medially; rostrum broadly rounded, with low dorsal ridge; anterior margins weakly concave; lateral projections broadly subtriangular, usually terminating in small spine; ventrolateral margin unarmed or occasionally with small spine; posterior margin broadly rounded. Ocular peduncles more than half length of shield; ocular acicles subtriangular, terminating in strong spine; corneae dilated. Sternite of 3rd maxillipeds with small spine on each side of midline. Antennular peduncle exceeding distal margin of corneae by full length of ultimate segment. Antennal peduncle (Fig. 20a) exceeding distal margin of cornea by at most 0.25 length of 5th segment; 3rd segment with strong ventromesial distal spine; 2nd segment with dorsolateral distal angle produced, terminating in strong spine; acicles at most slightly exceeding distal margin of corneae, mesial margin armed with 8 to 15 spines; flagellum with series of short setae (< 1 article in length) and long setae (> 3 articles in length) every 8 to 20 articles. Chelipeds markedly dissimilar, with some iridescence and moderately dense setae. Right cheliped (Figs 19c–e, 20b–d) with chela less than twice as long as broad (males), or about as long as broad (females); fingers curved ventromesially; dactyl with concave ventromesial face; palm with irregular rows of small spines medially on dorsal face, and dorsolateral and dorsomesial margins well delimited by row of spines; mesial face of palm rounded, with small spines or tubercles. Left cheliped (Fig. 19b) with palm and carpus often weakly calcified; carpus with dorsodistal spine. Ambulatory legs (Fig. 19f–h) with ventromesial row of about 5 (occasionally up to 15) small corneous spines on dactyl, and dorsal and dorsomesial rows of long setae; carpus with small dorsodistal spine; merus of right 3rd pereopod unarmed, (rarely 1 or 2 small dorsal spines). Anterior lobe of sternite of 3rd pereopods with small marginal spine, setose. Fourth pereopod (Fig. 19i) with dactyl terminating in short, corneous claw; propodal rasp consisting of ovate scales. Uropods and telson (Fig. 19j) markedly asymmetrical. Telson lacking transverse suture separating anterior and posterior lobes; posterior lobes separated by U-shaped median cleft, terminal margins armed with often strongly curved corneous spines. Male 1st gonopods (Fig. 20e) each with weakly concave distal lobe; 2nd gonopods (Fig. 20f) each with distal segment nearly flat. Females with vestigial right 2nd pleopod.

**Colour.** [Based on Miyake (1982: 118, pl. 40, fig. 1), Baba *et al.* (1986: 146, pl. 302), and Imafuku (1992: 234)]. Carapace light orange. Left cheliped, and 2nd and 3rd pereopods, light pink with two orange-red spots on mesial and lateral faces of meri, carpi, and propodi (spots on meri often partially fused). Right cheliped with chela, distal two-thirds of carpus, and distal third of merus, cream white; merus and carpus with orange-red portion proximally.

**Habitat and symbiotic associations.** Found in gastropod shells usually with actinian attached to shell.

**Distribution.** Indo Pacific: Gulf of Aden; Bay of Bengal; Japan; Philippines; Indonesia; and Australia. Depth: 202 to 1000 m.

**Affinities.** As previously mentioned, *Oncopagurus monstrosus* is similar to *O. indicus*, and often the two are difficult to separate. Individuals of *O. monstrosus* grow to a larger size than *O. indicus*. The most reliable characters in distinguishing between the two include size, development of ocular peduncles and corneae, and armature of the merus of the right 3rd pereopod (see "Affinities" under *O. indicus*).

**Remarks.** Because of the potential for confusion of this species with *O. indicus*, a lectotype is herein selected for *O. monstrosus*.

De Saint Laurent (1972) questionably synonymised *Eupagurus brevimanus* Yokoya, 1933, with *Parapagurus monstrosus* Alcock, 1894. From Yokoya's brief description it is not possible to confirm whether his taxon is indeed a synonym of *Oncopagurus monstrosus*, and his specimens are probably no longer extant.

### *Oncopagurus minutus* (Henderson, 1896)

Fig. 21

*Parapagurus minutus* Henderson, 1896: 531 (type locality: off the north Maldivé Atoll, *Investigator*, sta. 150, 719 fms (1308.6 m).—Alcock & Anderson, 1897, pl. 32, fig. 3, 3a.—Alcock, 1901: 222.—Alcock, 1905: 101, pl. 10, fig. 3.—De Saint Laurent, 1972: 108.

*Sympagurus minutus*.—Lemaitre, 1989: 37.—Lemaitre, 1994: 412.

?not *Parapagurus minutus*.—Thompson, 1943: 417 (See remarks under *Oncopagurus indicus* Alcock, 1905).

**Type material.** SYNTYPE, female (SL 2.3 mm), Indian Ocean, off north Maldivé Atoll, *Investigator*, sta. 150, 719 fms (1308.6 m), NHM 1896:9.8.24.

**Australian material.** NEW SOUTH WALES: 1 male (SL 2.5 mm), NZOI *Tangaroa*, U222, off Newcastle, 1075–1040 m, 9 Oct 1982, AM P40409.

**Other material.** INDONESIA: 1 male (SL 4.0 mm), Sulawesi (Celebes), Gulf of Tomini, off Limbe Is., *Albatross* sta. 5601, 01°13'10"N, 125°17'05"E, 1399 m, 13 Nov 1909, USNM 168943. 1 female (SL 2.2 mm), Siboga Exp. sta. 88, 00°34.6'S, 119°08.5'E, 1301 m, 20 Jun 1899, coll. M. Weber, ZMA De103.112. 1 male (SL 2.0 mm), Moluccas, S of Patiente Strait, off Doworra Is., *Albatross* sta. 5631, 00°57'S, 127°56'E, 1480 m, 2 Dec 1909, USNM 168944. 1 male (SL 3.5 mm), 1 female (SL 3.4 mm), Moluccas, Pitt Passage, off Gomomo Is., *Albatross* sta. 5636, 01°55'S, 127°42'30"E, 2308 m, 3 Dec 1909, USNM 168945. 2 males (SL 2.0, 2.6 mm), Celebes, Gulf of Boni, off Olang Point, *Albatross* sta. 5656, 03°17'40"S, 120°36'45"E, 885 m, 19 Dec 1909, USNM 168946.

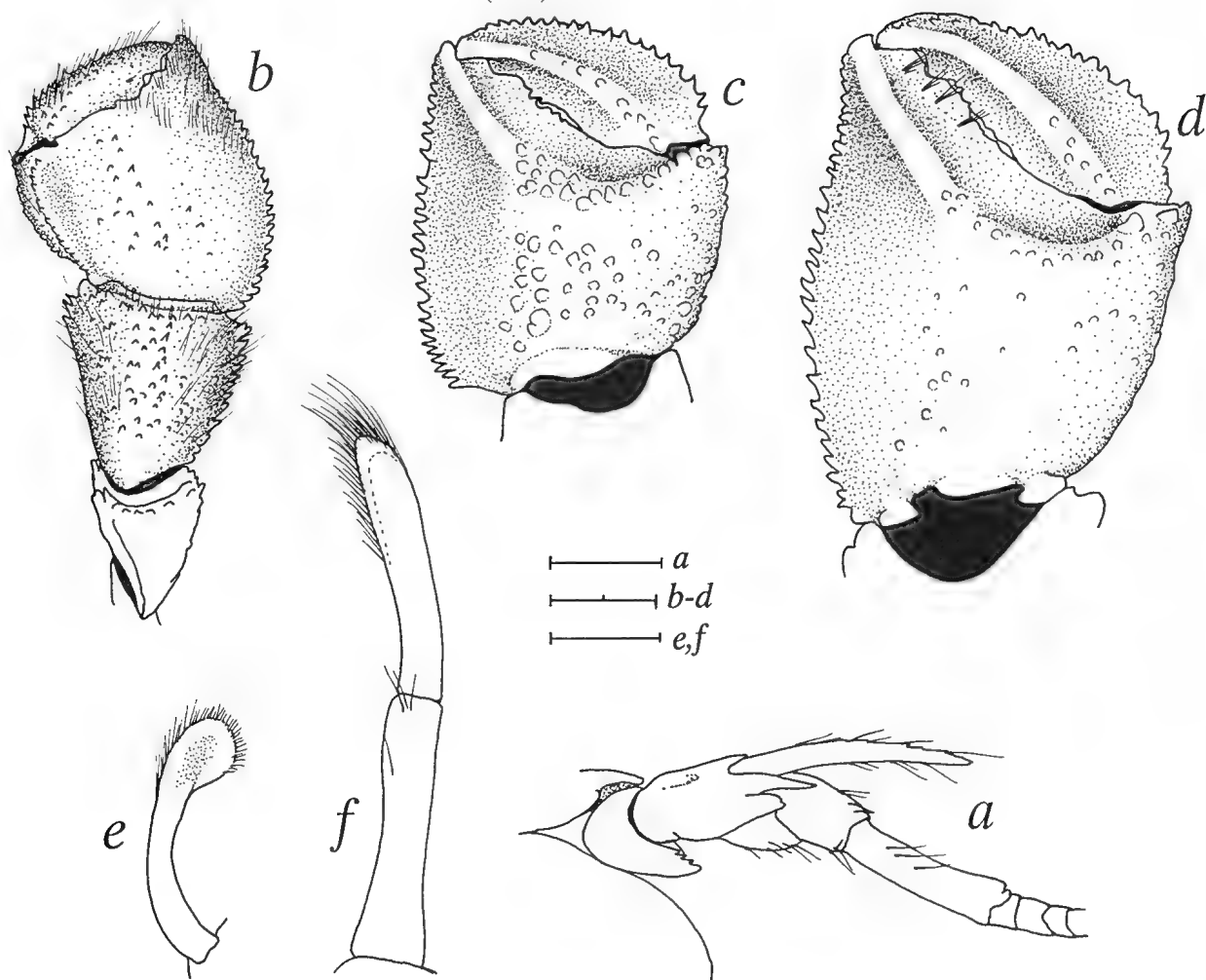
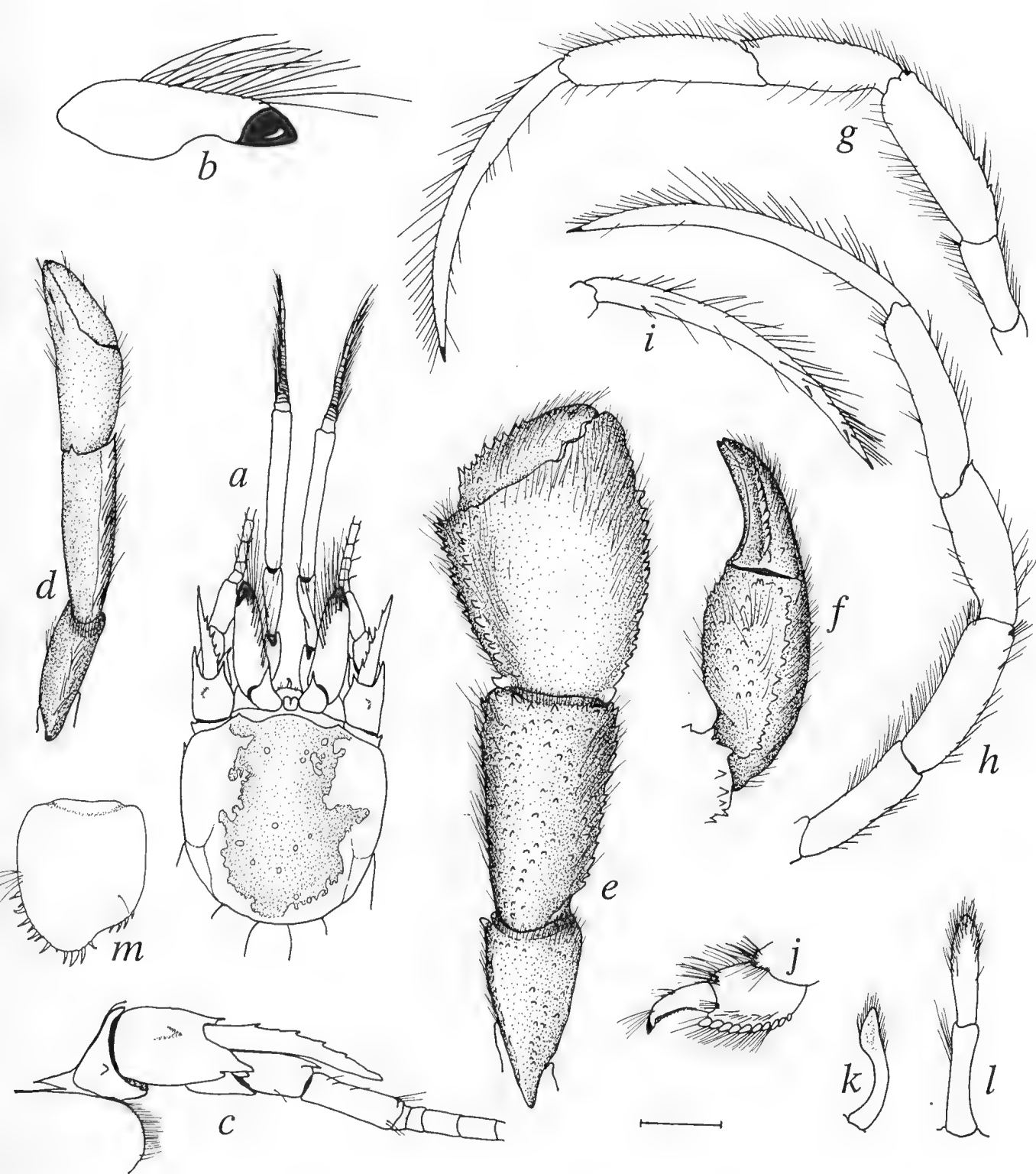


Fig. 20. *Oncopagurus monstrosus* (Alcock, 1894). a, right antennal peduncle, lateral; b, right cheliped of female; c, right chela of male, ventral; d, right chela of male, ventral; e, male right 1st gonopod, mesial; f, male right 2nd gonopod, posterior. Scales = 1 mm (a), 2 mm (b-d), 0.5 mm (e,f). (a,e,f, lectotype male [SL 4.2 mm], Bay of Bengal, USNM 156566; b, female [SL 3.4 mm], Indonesia, USNM 168939; c, male [SL 4.2 mm], Indonesia, USNM 168940; d, male [SL 5.1 mm], Philippines, USNM 168931).

**Diagnosis.** Shield (Fig. 21a) as long as broad; dorsal surface weakly calcified medially; rostrum broadly rounded, with short, low dorsal ridge; anterior margins weakly concave; lateral projections subtriangular, terminating in small spine; ventrolateral margin with small spine (not always visible in dorsal view); posterior margin broadly rounded. Ocular peduncles more than half length of shield, diminishing in width distally, and with long setae dorsally; ocular acicles subtriangular, terminating in strong spine; corneae cone-shaped (Fig. 21a,b), maximum width subequal to distal width of peduncle. Sternite of 3rd maxillipeds with small spine on each side of midline. Antennular peduncle exceeding distal margin of corneae by half or more length of penultimate segment. Antennal peduncle (Fig. 21c) slightly exceeding distal margin of cornea; 3rd segment with strong ventromesial distal spine; 2nd segment with dorsolateral distal angle produced, terminating in strong spine, mesial margin with small spine on dorsodistal angle; acicles at most slightly exceeding distal margin

of corneae, mesial margin armed with 5 to 7 spines; flagellum with setae 1 to 2 flagellar articles in length. Chelipeds markedly dissimilar, with moderately dense setae. Right cheliped (Fig. 21e,f) with fingers weakly curved ventromesially, dactyl with row of spines on mesial margin; palm with dorsal surface unarmed or at most with scattered small tubercles, dorsolateral and dorsomesial margins with row of spines, mesial face rounded and with few tubercles; carpus with numerous small tubercles or spines on dorsal surface. Left cheliped (Fig. 21d) with chela unarmed, well calcified; carpus with dorsolateral face weakly calcified, 1 dorsodistal and 1 laterodistal spine. Ambulatory legs (Fig. 21g-i) usually exceeding tip of extended right cheliped; dactyls evenly curved, about 1.9 as long as propodi, each with ventromesial row of about 5 (2nd) or 2 (3rd) small corneous spines, and dorsal and dorsomesial rows of long setae; carpus with small dorsodistal spine; ischium and merus of 2nd pereopod unarmed. Anterior lobe of sternite of 3rd pereopods unarmed or with small marginal



**Fig. 21.** *Oncopagurus minutus* (Henderson, 1896). a, shield and cephalic appendages; b, right ocular peduncle and cornea, lateral; c, right antennal peduncle, lateral; d, left cheliped; e, right cheliped; f, chela of same, mesial; g, left 2nd pereopod, lateral; h, left 3rd pereopod, lateral; i, dactyl of same, mesial; j, propodus and dactyl of left 4th pereopod, lateral; k, male left 1st gonopod, mesial; l, male left 2nd gonopod, anterior; m, telson. Scale = 1 mm (a,d-i), and 0.5 mm (b,c,j-m). (Male [SL 2.5 mm], New South Wales, AM P40409).



spine, setose. Fourth pereopod (Fig. 21j) with dactyl terminating in short, corneous claw; propodal rasp consisting of ovate scales. Uropods and telson markedly asymmetrical (Fig. 21m); telson lacking transverse suture; posterior lobes separated by shallow, U-shaped median cleft, terminal margins armed with often curved corneous spines. Male 1st gonopods (Fig. 21k) each with weakly concave distal lobe; 2nd gonopods (Fig. 21l) each with distal segment nearly flat. Females with vestigial right 2nd pleopod.

**Habitat and symbiotic associations.** Unknown, probably gastropod shells.

**Distribution.** Indo Pacific: Maldives; Indonesia; and Australia. Depth: 800 to 2308 m.

**Affinities.** This species, and *Sympagurus acinops* Lemaitre, 1989, from the eastern and western Atlantic Ocean, are the only parapagurids with subconical corneae. Other than in generic characters, the two species differ markedly in the length and armature of the antennal acicles, armature of chelipeds, and degree of development of male gonopods (see Lemaitre, 1989: 52, figs 24–27).

**Remarks.** De Saint Laurent (1972: 108) mentioned (without name) a form from the eastern Pacific (Galápagos Islands; Gulf of Panamá) which she considered close to, or conspecific with *O. minutus*. She did not, however, discuss such taxon any further.

### *Oncopagurus cidaris* n.sp.

Figs 22, 23

**Holotype.** Male (SL 2.6 mm), off Tully, Queensland, CIDARIS I sta. 1–3, 18°07.9'S, 147°35.7'E, epibenthic sledge, ORV *Franklin*, 956–969 m, 6 May 1986, coll. JCU, QM W16596.

**Paratypes.** QUEENSLAND: 2 males (SL 2.2, 2.7 mm), off Tully, CIDARIS, sta. 16–3, ORV *Franklin*, 17°47'S, 148°13'E, epibenthic sledge, 1141–1102 m, 10 May 1986, coll. JCU, QM W16506, 16508. 3 males (SL 2.4–2.7 mm), 1 female (SL 2.3 mm), 2 females ovig. (SL 2.7, 2.8 mm) off Tully, CIDARIS I, sta. 49–2, ORV *Franklin*, 17°51'S, 147°10'E, epibenthic sledge, 904–916 m, 17 May 1986, coll. JCU, QM W16496, USNM 270107. 3 males (SL 2.6–2.9 mm), 2 females ovig. (SL 2.5, 2.6 mm), same station data as holotype, QM W16596.

NEW SOUTH WALES: 1 male (SL 3.8 mm), E of Bass Point, FRV *Kapala*, sta. K75-02-16, 34°29–35'S, 151°19–17'E, 439–457 m, 30 Jun 1975, AM P20754. 1 female ovig. (SL 3.2 mm), off Newcastle, NZOI *Tangaroa*, cruise U223, 1150–951 m, 10 Oct 1982, AM P40390.

**Description.** Shield (Fig. 22a) as broad as long; dorsal surface weakly calcified on usually more than half of surface, and scattered short setae; rostrum broadly rounded, weakly produced, with short mid-

dorsal ridge; anterior margins weakly concave; lateral projections subtriangular, terminating bluntly; anterolateral margins sloping; posterior margin broadly rounded; ventrolateral margins of shield each with small spine. Anterodistal margin of branchiostegite rounded, unarmed, setose.

Ocular peduncles more than half length of shield, with dorsal row of long setae. Cornea width subequal to distal width of ocular peduncle. Ocular acicles subtriangular, terminating in strong spine; separated basally by less than basal width of 1 acicle.

Antennular peduncle long, slender, exceeding distal margin of cornea by entire length of ultimate segment. Ultimate segment twice as long as penultimate segment, with scattered setae. Basal segment with strong ventromesial spine; lateral face with distal subrectangular lobe armed or with 1 small spine, and strong spine proximally. Ventral flagellum with 5 to 6 articles.

Antennal peduncle (Fig. 23a) reaching distal margin of cornea. Fifth segment unarmed, but with scattered setae. Fourth segment with strong dorsodistal spine. Third segment with strong ventromesial distal spine. Second segment with dorsolateral distal angle produced, terminating in strong, simple spine; mesial margin with spine on dorsodistal angle. First segment with 1 small spine on lateral face; ventromesial angle produced, with 3 to 4 small spines laterally. Antennal acicles slightly curved outward (in dorsal view), at most slightly exceeding distal margins of corneae, terminating in strong spine; mesial margin armed with row of 5 to 9 spines, setose. Flagellum long, exceeding extended right cheliped and ambulatory legs, articles with numerous setae < 1 to 3 flagellar articles in length (Fig. 23b).

Mandible with 3-segmented palp. Maxillule (Fig. 23c) with external lobe of endopod weakly developed, internal lobe with 1 long seta. Maxilla with endopod exceeding distal margin of scaphognathite. First maxilliped with endopod exceeding exopod in distal extension. Second maxilliped without distinguishing characters. Third maxilliped (Fig. 23d) with crista dentata of about 8 corneous-tipped teeth; coxa and basis each with 1 tooth mesially. Sternite of 3rd maxillipeds with small spine on each side of midline.

Chelipeds markedly dissimilar. Right cheliped (Fig. 22c,d) massive, with moderately dense, plumose setae on distal half of chela. Fingers curved ventromesially, terminating in small, usually blunt corneous claw; cutting edges with irregularly-sized calcareous teeth. Dactyl slightly shorter than length of mesial margin of palm, set at strongly oblique angle to longitudinal axis of palm; mesial margin broadly curved, well defined by row of blunt or sharp spines diminishing in size distally; dorsal face with scattered small tubercles, ventral face smooth, ventromesial face concave. Fixed finger broad at base, dorsal and ventral faces smooth. Palm longer than broad, lateral margin well delimited by row of blunt to sharp spines; mesial face rounded, with scattered small tubercles; dorsomesial margin delimited by row



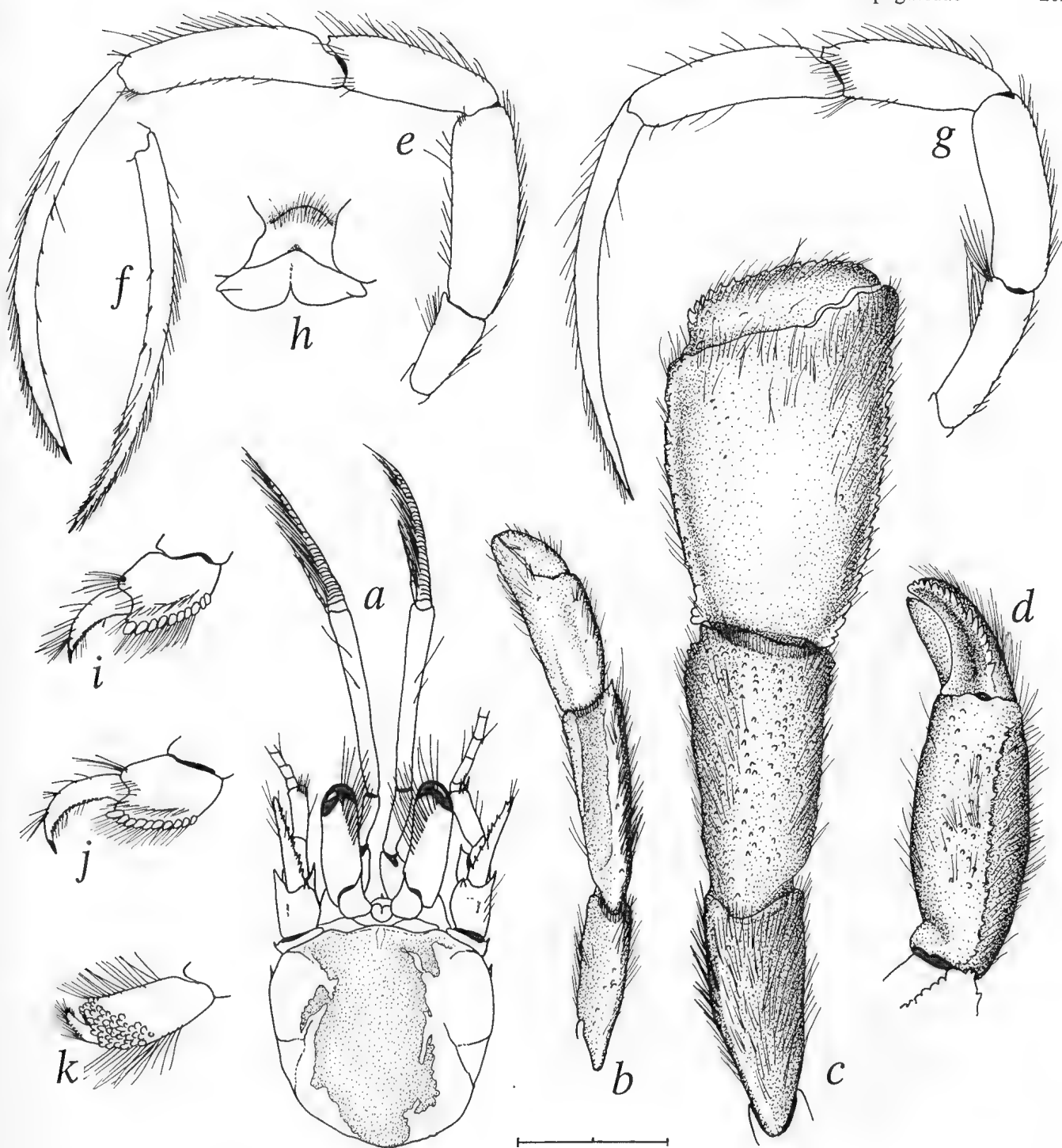


Fig. 22. *Oncopagurus cidaris* n.sp. a, shield and cephalic appendages; b, left cheliped; c, right cheliped; d, chela of same, mesial; e, left 2nd pereopod, lateral; f, dactyl of same, mesial; g, left 3rd pereopod, lateral; h, sternite of 3rd pereopods, ventral; i, propodus and dactyl of left 4th pereopod of male, lateral; j, propodus and dactyl of left 4th pereopod of female, lateral; k, propodus and dactyl of left 5th pereopod, lateral. Scale = 2 mm. (Same station data as holotype, Queensland, QM W16596: a, paratype male [SL 2.9 mm]; j, paratype female [SL 2.6 mm]).

of blunt or sharp spines; dorsal surface smooth except for scattered small tubercles; ventral surface smooth. Carpus with dorsolateral margin rounded or sometimes well delimited distally by row of spines; dorsal face with numerous small spines or tubercles; ventromesial margin

with row of spines; ventral face with scattered small tubercles. Merus with row of long bristles and scattered tubercles on dorsal surface; ventromesial margin with row of spines. Ischium and coxa unarmed, but with ventromesial row of setae.

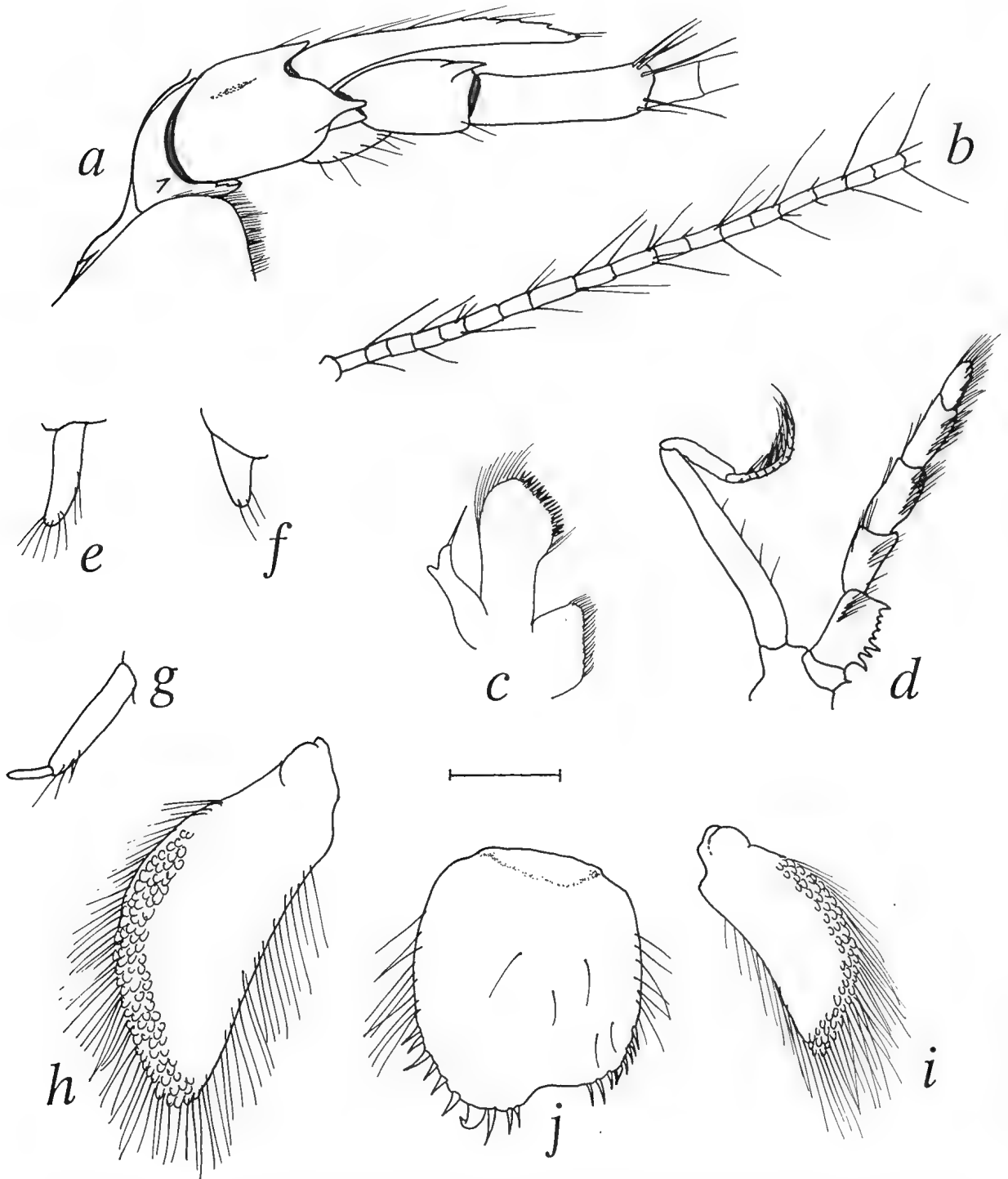


Fig. 23. *Oncopagurus cidaris* n.sp. a, right antennal peduncle, lateral; b, proximal one-third of antennal flagellum; c, left maxillule, internal; d, left 3rd maxilliped, internal; e, male left 2nd pleopod; f, male right 2nd pleopod; g, male left 2nd pleopod; h, i, exopod of uropods, dorsal: h, left; i, right; j, telson. Scale = 0.5 mm (a,c,e-j), and 1 mm (b,d). (Same station data as holotype, 'Queensland, QM W16596: a-f, h-j, paratype male [SL 2.9 mm]; g, male [SL 2.7 mm]).

Left cheliped (Fig. 22b) usually weakly well calcified on merus and carpus. Fingers terminating in small corneous claw; dorsal and ventral surfaces unarmed except for scattered tufts of setae; cutting edge of dactyl with row of minute, fused corneous teeth; cutting edge of fixed finger with row of regularly

spaced, small, evenly-sized teeth. Dactyl shorter than palm in length. Palm unarmed except for scattered setae on dorsal face and long setae on dorsomesial margin; ventral face smooth. Carpus with strong dorsodistal spine; dorsal margin with long setae; ventral face smooth. Merus with long setae on dorsal

margin; ventral face smooth. Ischium and coxa unarmed, but with ventromesial row of setae.

Ambulatory legs (Fig. 22e–g) similar right from left, exceeding extended right cheliped by approximately 0.25 length of dactyl. Dactyl broadly curved, twice as long as propodus, and terminating in sharp corneous claw; with dorsal and dorsomesial rows of long setae, and ventromesial row of about 7 to 9 slender corneous spines. Propodus with row of setae on dorsal margin. Carpus with small, blunt or sharp dorsodistal spine, and long setae dorsally. Merus with setae on dorsal margin. Ischium and coxa unarmed. Anterior lobe of sternite of 3rd pereopods (Fig. 22h) rounded, setose, unarmed.

Fourth pereopod (Fig. 22i,j) semichelate. Dactyl terminating in sharp corneous claw, and longer and more strongly curved in females than in males; with ventrolateral row of small corneous spinules. Propodus longer than broad, rasp formed of 1 row of rounded scales. Carpus with long setae on dorsal margin. Merus with rows of long setae on dorsal and ventral margins.

Fifth pereopod (Fig. 22k) semichelate. Propodal rasp extending to mid-length of segment.

Uropods and telson (Fig. 23h–j) markedly asymmetrical. Telson lacking transverse suture; dorsal surface with scattered setae; posterior lobes separated by shallow cleft, terminal margin of lobes armed with long, often strongly curved corneous spines.

Males lacking 1st gonopods; 2nd pair of gonopods (Fig. 23e–f) weakly developed, asymmetrical, left usually 1-segmented or occasionally 2-segmented with short distal segment (Fig. 23e,g), right 1-segmented, rudimentary or absent (Fig. 23f). Females with vestigial 2nd right pleopod.

**Habitat.** Found inhabiting gastropod shells.

**Distribution.** Known so far only from Australia. Depth: 439 to 1150 m.

**Etymology.** The specific name is given in recognition of the fruitful CIDARIS expeditions.

**Affinities.** This new species superficially resembles *O. tuamotu* (Lemaitre, 1994). The two species differ in several important characters (see Lemaitre, 1994: 407, figs 24–26, 28i). In *O. cidaris*, the right palm is distinctly longer than broad, and the ventromesial margin is rounded, unarmed, and the mesial face is not expanded distally (Fig. 22c,d); in *O. tuamotu* the palm is broader than long, the ventromesial margin is well delimited by a row of spines, and the mesial face is expanded distally. In the new species the dactyls of the ambulatory legs are more slender (Fig. 22e–g) than in *O. tuamotu*; the dactyl of the 4th pereopod is longer and more strongly curved in females than in males (Fig. 22i,j), whereas in *O. tuamotu* the dactyl is similar in both sexes. Although males of both species have asymmetrical 2nd gonopods, those of *O. cidaris* are less developed. In males of *O. cidaris*, the right 2nd gonopod can consist of a short bud (Fig. 23f), or sometimes is absent; the left 2nd gonopod is two to three times as

long as the right, and can consist of one, or occasionally two segments (Fig. 23e,g). In *O. tuamotu*, the 2nd gonopods are two-segmented on both sides.

**Remarks.** In addition to this new species, three other *Oncopagurus* species also lack 1st gonopods in males, *O. haigae* (De Saint Laurent, 1972) *O. orientalis* (De Saint Laurent, 1972) and *O. tuamotu* (Lemaitre, 1994). This condition in males has evolved in other parapagurid genera as well. Males of five species of *Paragiopagurus* n.gen. also lack 1st gonopods, *P. acutus*, *P. bicarinatus*, *P. hirsutus*, *P. hobbiti* (Macpherson, 1983), and *P. ruticheles* A. Milne Edwards, 1891, of which only the first three have been found so far in Australian waters.

### *Paragiopagurus* n.gen.

*Sympagurus*.—Lemaitre, 1989: 36 (in part).

**Diagnosis.** Eleven pairs of phyllobranchiate or intermediate gills. Shield about as broad as long; dorsal surface often with irregularly-shaped, weakly calcified areas medially. Cornea weakly to moderately dilated. Fourth segment of antennal peduncle armed with dorsodistal spine. Epistomial spine straight, or absent. Right chela usually with well delimited dorsomesial and dorsolateral margins; often operculate. Left cheliped well calcified, or sometimes weakly calcified on merus and carpus. Ambulatory legs with dactyls curved. Fourth pereopod with propodal rasp consisting of 1 or more rows of ovate corneous scales. Second abdominal somite with left pleuron terminating in small subtriangular lobe. Males usually with weakly to moderately developed paired 1st and 2nd gonopods; 1st gonopods sometimes absent; rarely with 2nd unpaired left pleopod.

**Species.** Included in this new genus are three taxa previously considered subspecies by De Saint Laurent (1972) that are herein elevated to specific rank, *Sympagurus acutus acutus* (De Saint Laurent, 1972), *S. a. bicarinatus* (De Saint Laurent, 1972), and *S. a. hirsutus* (De Saint Laurent, 1972); and also *S. boletifer* (De Saint Laurent, 1972), *S. bougainvillei* Lemaitre, 1994, *S. curvispina* (De Saint Laurent, 1974), *S. diogenes* Whitelegge, 1900, *S. hobbiti* (Macpherson, 1983), *S. macrocerus* (Forest, 1955), *S. pacificus* Edmondson, 1925, *S. pilimanus* (A. Milne Edwards, 1880), *S. rugosus* (De Saint Laurent, 1972), *S. ruticheles* (A. Milne Edwards, 1891), *S. spinimanus* (Balss, 1911), *S. tuberculosus* (De Saint Laurent, 1972), and *S. wallisi* Lemaitre, 1994.

**Type species.** *Sympagurus diogenes* Whitelegge, 1900. Gender: masculine.

**Etymology.** From the Greek *parageios*, pertaining to shallow water, and *pagourus*, crab. The name is in reference to the depth distribution of the type species of the genus, the shallowest so far known of all parapagurids.

Key to Australian species of *Paragiopagurus* n.gen.

1. Ventral face of right chela covered with prominent mushroom-like tubercles ..... *P. boletifer*
- Ventral face of right chela smooth, with small spines or tubercles ..... 2
2. Right cheliped with transverse furrows on ventral face of chela and ventrolateral face of carpus ..... *P. ruticheles*
- Right cheliped without transverse furrows on faces of chela or carpus ..... 3
3. Ocular acicles simple; males with paired 1st gonopods ..... *P. diogenes*
- Ocular acicles multifid; males lacking paired 1st gonopods ..... 4
4. Palm of right chela with ventromesial margin well delimited by row of spines, mesial face expanded distally (Fig. 27d,e) ..... *P. bicarinatus*
- Palm of right chela with ventromesial face not delimited by row of spines, mesial face not expanded distally ..... 5
5. Dorsal face of right chela armed with strong spines (Fig. 28d) ..... *P. hirsutus*
- Dorsal face of right chela smooth or with weak scattered spines or tubercles (Fig. 25d) ..... *P. acutus*

*Paragiopagurus diogenes* (Whitelegge, 1900)

Fig. 14d,e, 24

*Sympagurus diogenes* Whitelegge, 1900: 172, pl. 34, fig 3 (type locality, by lectotype designation: 3km E of Port Hacking, New South Wales, sta. 35, 34°03.5'S, 151°12.5'E, 40–69 m).—Alcock, 1905: 173.—Lemaitre, 1989: 37.—Lemaitre, 1994: 412, fig. 27g.—Springthorpe & Lowry, 1994: 89.

*Parapagurus diogenes*.—Terao, 1913: 382.—Gordan, 1956: 338.—De Saint Laurent, 1972: 108.—Miyake, 1960: 90, pl. 45, fig. 2.—Miyake, 1975: 326, pl. 117, figs 3, 6.—Miyake, 1978: 72, figs 26, 27b, pl. 4, fig. 5.—Miyake, 1982: 119, pl. 40, fig. 2.—Baba *et al.*, 1986: 301, fig. 145.—Yu & Foo, 1991: 70, unnumbered pl.

Not *Sympagurus arcuatus diogenes* Hale, 1941: 279. (See remarks)

**Type material.** *Thetis* Exp., New South Wales: LECTOTYPE (herein selected): 1 female (SL 7.9 mm), 3 km E of Port Hacking, sta. 35, 34°03.5'S, 151°12.5'E, 22–38 fms (40–69 m), 10 Mar 1898, coll. E. R. Waite, AM G2379. PARALECTOTYPES: 2 males (SL 3.9(dry), 4.4 mm), 12 km E of Wollongong, sta. 48, 34°27'S, 151°04'E, 55–56 fms (101–102 m), 18 Mar 1898, coll. E.R. Waite, AM G2380.

**Australian material.** WESTERN AUSTRALIA: 1 female ovig. (SL 4.7 mm), between Shark Bay and Onslow, 1966, coll. W.W. Poole Bros, WAM 1167–86. 1 male (SL 2.7 mm), 1 female ovig. (SL 3.2 mm), NW Bluff Pt., CSIRO sta. 204, 27°18'S, 113°16'E, 99 m, 9 Oct 1963, WAM 1199–85. 2 males (SL 4.3, 5.1 mm), about 97 km W of Dongara, MV *Sprightly*, sta. 34M, 29°07.2'S, 113°56.4'E, 141 m, 19 Feb 1976, WAM 1092–86. 8 males (SL 3.0–6.3 mm), 7 females (SL 3.2–5.1 mm), 2 females ovig. (SL 4.3, 4.7 mm), 1 juv. sex indet. (SL 2.5 mm), about 92 km W of Dongara, MV *Sprightly*, sta. 18M, 29°11'S, 113°52.2'E, 137 m, 17 Feb 1976, WAM 1144–86, 1299–86, 1301–86. 6 males (SL 5.7–9.2 mm), W of Dongara, HMAS *Diamantina*, sta. 55, 29°15'S, 114°01'E, 146 m, 20 Mar 1972, WAM 1838–86. 2 males (SL 3.7, 5.4 mm), 1 female ovig. (SL 5.4 mm), about 73 km W of Cliff Head, MV *Sprightly*, sta. 22M, 29°31.7'S, 114°15.5'E, 145 m, 18 Feb 1976, WAM 1113–86. 1 male (SL 6.7 mm), about 69 km W of Cliff Head, MV *Sprightly*, sta. 24M, 29°34.1'S, 114°17.4'E, 126 m, 18 Feb 1976, WAM 1098–86. 1 female (SL 7.9 mm), NW of Beagle Is., HMAS *Diamantina*, sta. 53, 29°48'S, 114°20'E, 216–256 m, 20 Mar 1972, WAM 1759–86. 1 male (SL 5.5 mm), about 40 km W of Jurien Bay, MV *Sprightly*, sta. 1M, 30°21'S, 114°38'E, 15 Feb 1976, WAM 1326–86. 2 males (SL 5.7, 7.3 mm), 1 female (SL 4.3 mm), 1 female ovig. (SL 5.2 mm), SW of Jurien Bay, HMAS *Diamantina*, sta. 107, 30°29'S, 114°40'E, 146 m, 9 Dec 1970, WAM 2207–86. 1 juv. sex indet. (SL 2.5 mm), NW of Green Is., HMAS *Diamantina*, sta. 68(3), approx. 30°34'S, 114°44'E, 128 m, 22 Mar 1972, WAM 1755–86. 7 males (SL 3.2–8.7

mm), 4 females (SL 4.0–6.1 mm), NW of Green Is., HMAS *Diamantina*, sta. 68(1), 30°37'S, 114°44'E, 146–139 m, 22 Mar 1972, WAM 1696–86, 1923. 1 male (SL 8.2 mm), NW Green Is., HMAS *Diamantina*, sta. 68/2, 30°37'S, 114°44'E, 137–144 m, 22 Mar 1972, WAM 1697–86. 7 males (SL 3.9–6.0 mm), 1 female (SL 5.2 mm), SW of Jurien Bay, HMAS *Diamantina*, sta. 108, 30°38'S, 114°47'E, 110 m, 9 Dec 1970, WAM 1716–86. 1 male (SL 7.6 mm), W. of Lancelin, HMAS *Diamantina*, sta. 37, 30° 55'S, 114° 48'E, 146 m, 27 Nov 1970, WAM 903–89. 1 male (SL 6.9 mm), 1 female (SL 7.5 mm), NW of Rottnest Is., *Bluefin*, 146 m, 15 Sep 1965, WAM 1998–86. 2 males (SL 4.2, 4.6 mm), W of Lancelin, HMAS *Diamantina*, sta. 70, 31°00'S, 114°52.5'E, 146–150 m, 23 Mar 1972, WAM 1744–86. 1 male (SL 6.9 mm), 1 female ovig. (SL 4.3 mm), W of Guilderton, HMAS *Diamantina*, sta. 77, 31°34'S, 115°06'E, 106–110 m, 23 Mar 1972, WAM 1695–86, 1747–86. 1 male (SL 8.1 mm), W of Rottnest Is., HMAS *Diamantina*, sta. 1, 32°00'S, 115°12'E, 150 m, 5 Mar 1976, coll. B. Hutchins *et al.*, WAM 393–86. 1 male (SL 4.9 mm), 2 females ovig. (SL 5.7, 8.2 mm), W of Rottnest Is., HMAS *Diamantina*, sta. 78, 32°00'S, 115°15'E, 146–150 m, 23 Mar 1972, WAM 1699–86, 1701–86. 2 males (SL 6.4, 6.4 mm), 1 female (SL 4.6 mm), SW of Rottnest Is., *Bluefin*, 146–152 m, 17 Sep 1965, coll. C. Disley, WAM 395–86, 832–86, 2011–86. 1 female (SL 5.2 mm), W of Garden Is., HMAS *Diamantina*, sta. 32, 32°15'S, 115°07'E, 210–212 m, 17 Mar 1972, WAM. 2 females (SL 3.7, 6.7 mm), W of Garden Is., HMAS *Diamantina*, sta. 34, 32°19'S, 115°07'E, 148–154 m, 18 Mar 1972, WAM 1712–86. 1 male (SL 7.2 mm), W of Manduram, HMAS *Diamantina*, sta. 4, 32°33'S, 115°04'E, 110 m, 23 Nov 1970, WAM 1702–86. 1 female (SL 3.6 mm), 2 females ovig. (SL 4.5, 6.0 mm), NW of Bunbury, HMAS *Diamantina*, sta. 8, 32°57'S, 114°48'E, 139–122 m, 15 Mar 1972, WAM 1703–86. 2 males (SL 6.4, 5.1 mm), 1 female (SL 5.8 mm), 1 female ovig. (SL 6.0 mm), NW of Bunbury, HMAS *Diamantina*, sta. 6II, 33°00'S, 114°37'E, 219–221 m, 17 Mar 1972, WAM. 2025–86. 5 males (SL 3.6–5.5 mm), 4 females (SL 2.7–4.5 mm), southwest coast of Western Australia, HMAS *Diamantina*, [no other data], WAM 1711–86.

QUEENSLAND: 1 male (SL 7.1 mm), 1 female (SL 5.3 mm), 2 females ovig. (SL 6.2, 7.0 mm), Marion Plateau, FRV *Soela*, sta. 0685-03, 22°34.8'S, 153°30.7'E, 678–695 m, 16 Nov 1985, NTM Cr 006856. 1 male (SL 5.5 mm), 18 mi (33.3 km) N of Cape Moreton, FV *Gemini*, trawled, 113–119 m, sand and dead shell, 19–20 Mar 1970, coll. F. Wallace, QM W4423. 3 males (SL 6.5–8.0 mm), off Cape Moreton, 119 m, trawled, [no date], coll. D. Harris, QM W3336. 2 males (SL 6.3, 6.5 mm), 1 female ovig. (SL 6.9 mm), sta. 29, Nimbus Creek, Moreton Bay, [no depth], Jan 1968, coll. A.J. Bruce, WAM 203-94. 2 males (SL 6.6, 7.0 mm), off Coondra, coll. R. Elks, QM W3333. 1 male (SL 5.8 mm), Mooloolaba (ca 130 km N of Brisbane), 126–128 m, 12–14 Aug 1967, coll. R. Elks, QM W2848.

NEW SOUTH WALES: 4 males (SL 4.3–7.5 mm), 2 females (SL 4.3–5.1 mm), 1 female ovig. (SL 5.7 mm), E of Tweed Heads, FRV *Kapala*, sta. 78-09-09/10, 28°14'S, 153°50'E, 140 m, 2 Jun 1978, AM P40404. 1 male (SL 7.0 mm), E of Brunswick Heads, FRV *Kapala*, sta. K78-09-16, 28°24'S, 153°31'E, 174 m, 3 Jun 1978, AM P40401. 2 males (SL 5.4, 6.7 mm), 1 female ovig. (SL 5.7 mm), N of North Solitary Is., FRV *Kapala*, sta. K78-16-08, 29°54'S, 153°36'E, 109 m, 2 Aug 1978, AM P40399. 23 males (SL 3.0–6.7 mm), 20 females (SL 3.2–5.8 mm), E of Tweed Heads, FRV *Kapala*,

sta. K78-17-15, 146 m, (no date), AM P40389. 2 males (SL 10.0, 10.3 mm), transect between Sydney and Port Stephens, FRV *Kapala*, 366 m, July 1972, AM P19610. 1 male (SL 8.2 mm), off Newcastle, coll. A. d'Ombraïn, AM P12327. 2 males (SL 7.9, 9.2 mm), N of Sydney, FRV *Kapala*, sta. K71-12-01, 33°40'S, 151°35'E, 137–146 m, 14 Jul 1972, AM P19631. 5 males (SL 4.0–7.8 mm), 2 females (SL 4.5, 5.4 mm), 1 female ovig. (SL 4.2 mm), E of Dangar Pt., Broken Bay, FRV *Kapala*, sta. K78-17-14, 201 m, 17 Aug 1978, AM P40393. 3 males (SL 6.3–9.4 mm), 1 female (SL 5.1 mm), 19 Jan 1973, coll. Shelf Benthic Survey, AM P40403, P40392. 1 male (SL 6.3 mm), E of Sydney, sta. 029, 33°49'S, 151°16'E, 19 Jan 1973, [no depth], coll. Shelf Benthic Survey, AM P40388. 1 male (SL 5.4 mm), 5.6 km E of North Head, sta. 901(I), 33°49'30"S, 150°21'48"E, 66 m, Apr 1973, coll. AM Shelf Benthic Survey, AM P20708. 2 males (SL 8.1, 8.9 mm), E of Malabar, Sydney, 33°50.6'S, 151°21'E, 66 m, 23 Jan 1973, coll. AM Shelf Benthic Survey, AM P39441. 2 males (SL 3.8, 7.8 mm), 3 females (SL 3.0–4.4 mm), 1 female ovig. (SL 4.4 mm), off Malabar, Sydney, sta. 25, 26 Jan 1973, coll. AM Shelf Benthic Survey, AM P20741. 5 males (SL 3.1–5.7 mm), 2.3 km E of Malabar, Sydney, AM Shelf Benthic Survey, sta. V, 33°59'27"S, 151°16'48"E, AM P40397. 1 male (SL 11.5 m), off Botany, 81 m, Aug 1921, AM P5594. 1 male (SL 10.9 mm), Burrawarra Hea, Bateman's Bay, 91 m, AM P9329. 1 male (SL 12.4 mm), 38 km NNE of Montague Is., 164 m, Sep 1926, AM P9312. 1 female (SL 8.7 mm), 16 km E of Montague Is., 137 m, 11 Jul 1925, AM P8218. 2 males (SL 8.3, 9.1 mm), off southern part of New South Wales coast, 73 m, AM P11435.

VICTORIA: 1 male (SL 10.8 mm), off Cape Everard, 119 m, Aug 1948, coll. W. French, NMV J10990.

**Diagnosis.** Intermediate gills. Shield (Fig. 24a) as broad as long; dorsal surface weakly calcified medially, and with low blister-like tubercles; rostrum broadly rounded, with short mid-dorsal ridge; anterior margins weakly concave; lateral projections subtriangular, with terminal spine; posterior margin broadly rounded. Ocular peduncles more than half length of shield, with dorsal longitudinal row of setae. Cornea slightly dilated. Ocular acicles subtriangular, terminating in strong spine usually directed anteromesially. Sternite of 3rd maxillipeds with small spine on each side of midline. Epistome with strong, straight spine. Antennular peduncle long, slender, exceeding distal margin of corneae by nearly entire length of ultimate segment. Antennal peduncle (Fig. 24b) exceeding distal margin of cornea by at most 0.20 length of 5th segment; 3rd segment with strong ventromesial distal spine; acicles curved outward (in dorsal view), not exceeding distal margin of corneae, and armed mesially with 4 to 7 strong spines; flagellum long, reaching to or slightly exceeding extended right cheliped, articles with very short setae interspersed with long setae every 5 to 15 articles. Chelipeds markedly dissimilar, glabrous or at most with scattered short setae, carpi and chelae usually iridescent dorsally. Right cheliped (Fig. 14d,e) with small tubercles or spines on dorsal surfaces of carpus and chela (tubercles or spines decreasing in size and number with increased size of individuals); fingers curved ventromesially; palm with

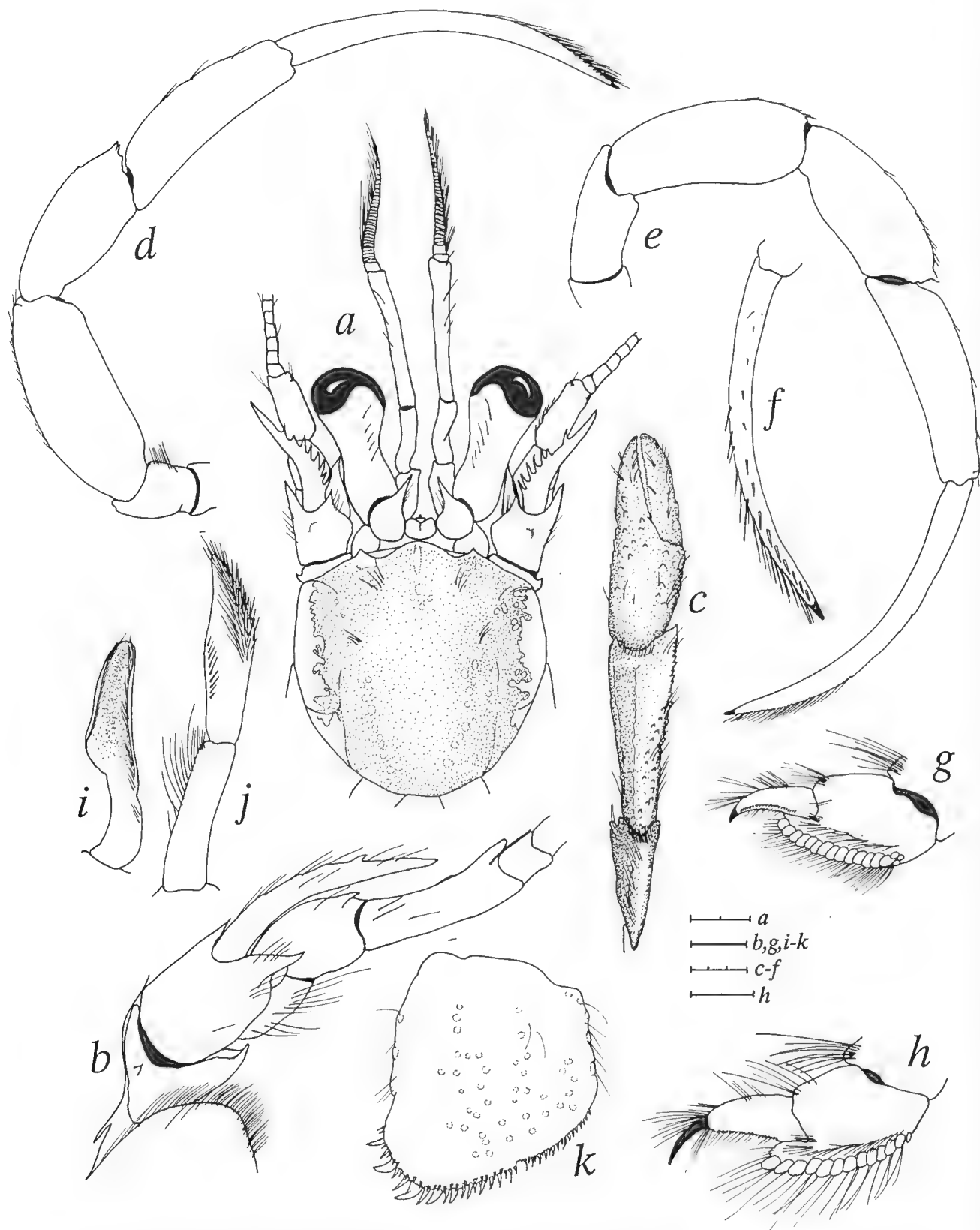


Fig. 24. *Paragiopagurus diogenes* (Whitelegge, 1900). a, shield and cephalic appendages; b, right antennal peduncle, lateral; c, left cheliped; d, right 2nd pereopod, lateral; e, right 3rd pereopod, lateral; f, dactyl of same, mesial; g, propodus and dactyl of male left 4th pereopod, lateral; h, propodus and dactyl of female left 4th pereopod, lateral; i, left male 1st gonopod, mesial; j, left male 2nd gonopod, anterior; k, telson. Scales = 2 mm (a), 1 mm (b,g,i-k), 3 mm (c-f), and 0.5 mm (h). (New South Wales: a-g,i-k, male [SL 8.1 mm], AM P39441; h, female [SL 4.0 mm], AM P40389).



dorsolateral margin well delimited by row of blunt to sharp spines, mesial face rounded. Left cheliped (Fig. 24c) with dorsolateral face of carpus frequently weakly calcified; chela with dorsomesial row of few small spines; carpus with irregular row of small spines dorsally. Ambulatory legs (Fig. 24d–f) reaching to tip of right cheliped, unarmed except for dorsodistal spine on carpus; dactyls approximately 1.8 times as long as propodus, each with ventromesial row of about 8 to 14 corneous spines. Anterior lobe of sternite of 3rd pereopods unarmed, or rarely with small blunt marginal spine. Fourth pereopod (Fig. 24g,h) with dactyl terminating in sharp corneous claw (longer and more slender in females than in males); propodal rasp consisting of 1 row of rounded scales. Uropods and telson markedly asymmetrical; telson (Fig. 24k) with weak transverse suture; dorsal surface usually with low, blister-like tubercles; posterior lobes separated by narrow cleft, terminal margin of lobes armed with numerous corneous spines (often strongly curved on left lobe). Male 1st gonopods (Fig. 24l) each with concave distal lobe; 2nd gonopods (Fig. 24j) each with distal segment setose on distomesial face, and row of short bristle-like setae on lateral margin. Females occasionally with paired 1st pleopods; with vestigial 2nd right pleopod.

**Distribution.** Western Pacific: Japan; China Sea; and Australia. Depth: 40 to 695 m.

**Colour.** In fresh specimens, general colour orange or reddish (in preservative, colour fades to cream white except on chelipeds where patterns remain for considerable time). Chelipeds with fingers cream white; dorsal surface of carpus and chela orange or reddish; iridescent, fading to white laterally. Walking legs orange or reddish, fading to cream white towards the dactyls. Carpi of chelipeds and walking legs each with dark red band proximally. Merus of right cheliped with dark red stripe dorsomesially. Carapace and chelae with small, scattered red spots.

**Affinities.** *Paragiopagurus diogenes* most closely resembles two species recently described from French Polynesia (as *Sympagurus*), *P. bougainvillei* (Lemaitre, 1994), and *P. wallisi* (Lemaitre, 1994). *Paragiopagurus diogenes* can be separated readily from those two species by differences in coloration, or in the absence of colour, by the weaker armature of the carpus and chela of the right cheliped in *P. diogenes* than in the two from French Polynesia.

**Remarks.** Whitelegge (1900: 177), in his description of *Sympagurus diogenes*, listed an "adult female" and a "young male" (AM G2379, G2380). He included measurements for one specimen without indicating sex; obviously they correspond to the female which is larger in size. While examining type material deposited in the Australian Museum, however, an additional male specimen was found labelled "co-type" (dry, and

catalogued under the same number as the other male, AM G2380). This dry male specimen was collected at the same date and locality as the male listed by Whitelegge (see Springthorpe & Lowry, 1994). In order to avoid any potential confusion, and considering that Whitelegge's species is the type of *Paragiopagurus* n.gen., a lectotype is herein selected for Whitelegge's taxon.

The female used by Whitelegge (1900) has paired 1st pleopods. It is not uncommon for this condition to occur in some female individuals of other parapagurid species, such as *Sympagurus pictus* Smith, 1883, and *S. dimorphus* (see Lemaitre, 1989). Whitelegge's (1900: pl. 34, fig. 3) photograph was evidently reversed during the printing process as it shows the larger cheliped on the left side rather than on the right.

Hale (1941) considered Whitelegge's (1900) *Sympagurus diogenes* (= *Paragiopagurus diogenes* [Whitelegge, 1900]) a subspecies of *S. arcuatus*, based on the dense pilosity of the right cheliped that he (Hale) observed in specimens from Tasmania and Macquarie Island. The surface of the chelipeds in *Paragiopagurus diogenes* is glabrous, at most with only scattered setae. Although Hale did not give any other information on his specimens, and they have not been available for examination, it is clear that they are not of *P. diogenes*, and instead represent some other undetermined species.

This species is among the most common parapagurids in Australian waters, and is frequently found in depths less than 100 m.

### *Paragiopagurus acutus* (De Saint Laurent, 1972)

Figs 25, 26

*Parapagurus acutus acutus* De Saint Laurent, 1972: 113, figs 7, 18 (type locality: Philippines, *Albatross* sta. 5222).

*Sympagurus acutus acutus*.—Lemaitre, 1989: 37.—Lemaitre, 1994: 412.

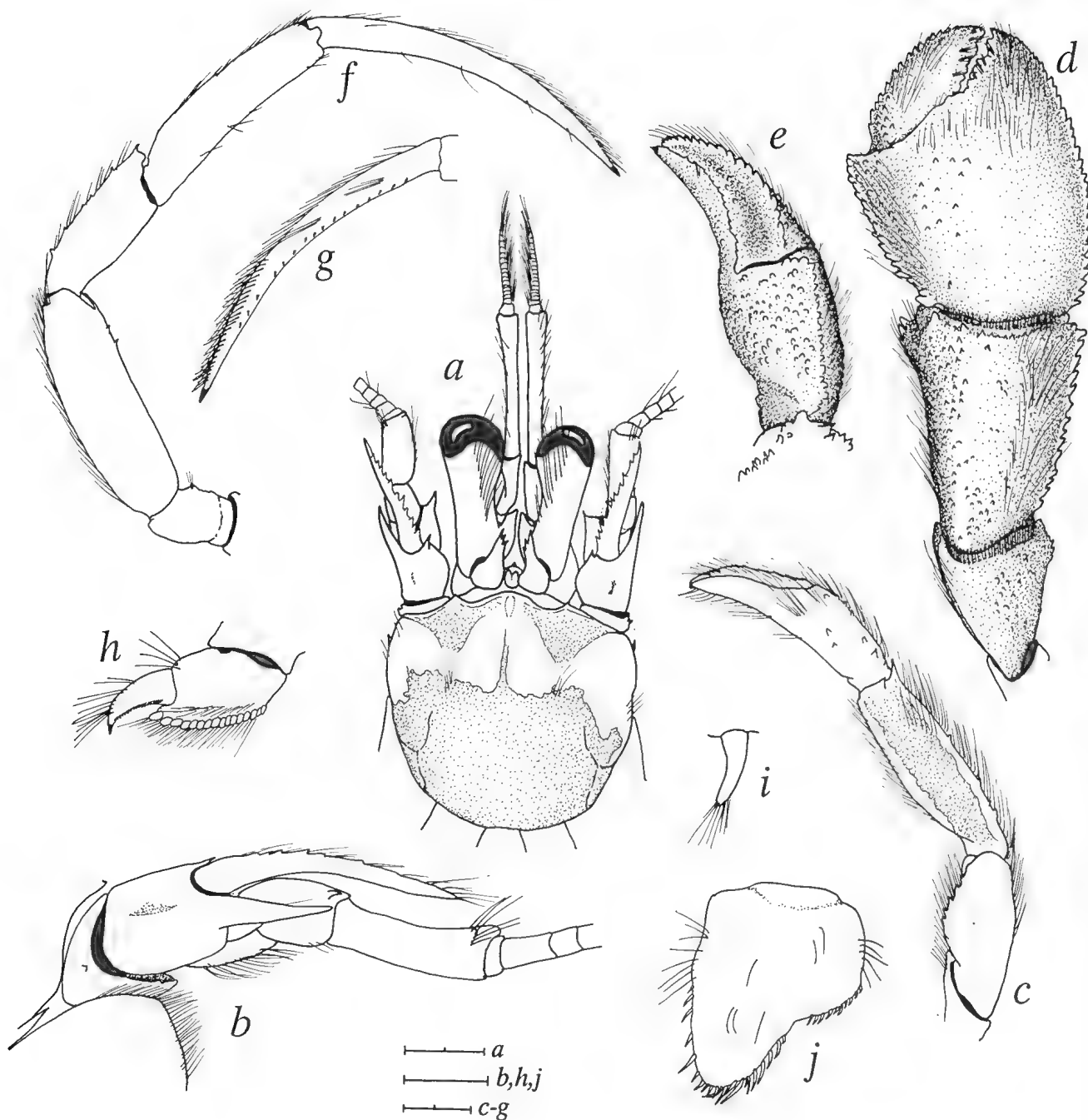
**Holotype.** Male (SL 5.6 mm), Philippines, 9.2 mi (17 km) NW of W San Andreas Is., between Marinduque and Luzon, *Albatross* sta. 5222, 13°38'30"N, 121°42'45"E, 357 m, 24 Apr 1908, USNM 168309.

**Australian Material.** WESTERN AUSTRALIA: 1 male (SL 4.6 mm), NW of Leveque, FRV *Soela*, sta. 01/84/065, 14°49.0'S, 121°36.1'E, 302–300 m, 12 Feb 1984, coll. S. Slack-Smith, WAM 1239–86.

**Other material.** (For meaning of asterisks see Materials and Methods). JAPAN: 1 male (SL 6.1 mm), Honshu, Uraga Strait, *Albatross* sta. 5094, 35°04'42"N, 139°38'20"E, 161 m, 26 Oct 1906, USNM 168973\*.

PHILIPPINES: 14 males (SL 3.4–6.0 mm), 9 females (SL 2.8–4.8 mm), Verde Is. Passage, off Matocot Point, *Albatross* sta. 5268, 13°42'N, 120°57'15"E, 311 m, 8 Jun 1908, USNM 168980\*. 7 males (SL 2.1–3.5 mm), between Cebu and Bohol, off Lauis





**Fig. 25.** *Paragiopagurus acutus* (De Saint Laurent, 1972), holotype male (SL 5.6 mm), Philippines, USNM 168309: a, shield and cephalic appendages; b, right antennal peduncle, lateral; c, left cheliped, dorsolateral; d, right cheliped; e, chela of same, mesial; f, right 2nd pereopod, lateral; g, dactyl of same, mesial; h, propodus and dactyl of left 4th pereopod, lateral; i, left 2nd pleopod, lateral; j, telson. Scales = 2 mm (a,c-g), and 1 mm (b,h,j).

Point, *Albatross* sta. 5412, 10°09'15"N, 123°52'E, 296 m, 23 Mar 1909, USNM 168977\*. 2 males (SL 2.7, 3.2 mm), between Cebu and Bohol, off Lauis Point, *Albatross* sta. 5411, 10°10'30"N, 123°51'15"E, 265 m, 23 Mar 1909, USNM 168976\*. 2 males (SL 4.2, 4.8 mm), Verde Is. Passage, off Matocot Point, *Albatross* sta. 5297, 13°41'20"N, 120°58'E, 362 m, 24 Jul 1908, USNM 168975\*. 1 female (SL 4.1 mm), Verde Is. Passage, off Matocot Point, *Albatross* sta. 5269, 13°39'50"N, 120°59'30"E, 402 m, 8 Jun 1908, USNM 168974\*.

INDONESIA: 1 male (SL 5.2 mm), Borneo, Darvel Bay, off Sibutu Is., *Albatross* sta. 5579, 04°54'15"N, 119°09'52"E, 320 m, 25 Sep 1909, USNM 168978\*. 1 female (SL 6.4 mm), Borneo, Sibuko Bay, off Silungan Is., *Albatross* sta. 5592, 04°12'44"N, 118°27'44"E, 558 m, 29 Sep 1909, USNM 168979\*. 1 female (SL 5.8 mm), Den danske Kei Ekspd. 1922, sta. 59, 05°28'S, 132°36'E, 385 m, 12 May 1922, ZMK. 4 males (SL 3.3–7.4 mm), Den danske Kei Ekspd. 1922, sta. 44, 05°39'S, 132°23'E, 268 m, 30 Apr 1922, ZMK. 1 male

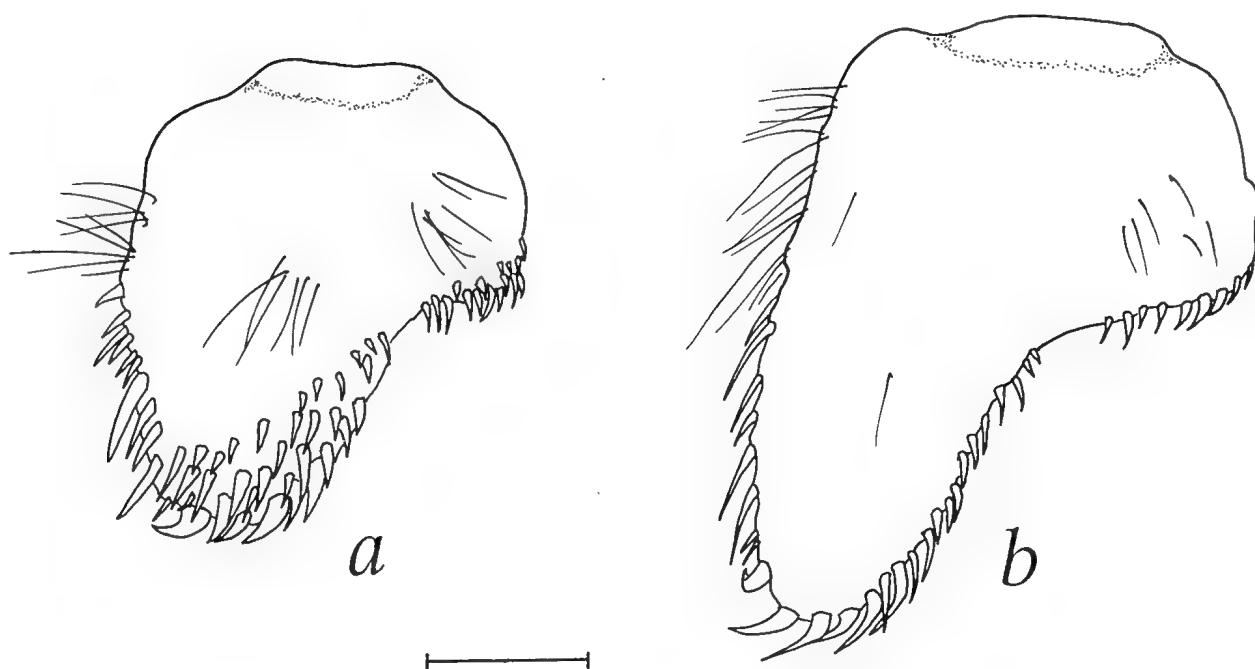


Fig. 26. Telsons of *Paragiopagurus acutus* (De Saint Laurent, 1972). Paratypes, Indonesia, ZMK: a, female (SL 6.8 mm); b, male (SL 8.0 mm). Scale = 1 mm.

(SL 6.7 mm), Den danske Kei Ekspd. 1922, sta. 51, 05°40'10"S, 132°21'E, 263 m, 3 May 1922, ZMK. 3 males (SL 2.1–8.0 mm), 2 females (SL 2.0, 3.3 mm), 4 females ovig. (SL 2.6–6.8 mm), Th. Mortensen's Java-S. Afrika Exp. 1929–30, sta. 7, 08°29'S, 114°40'E, 200 m, 5 Apr 1929, ZMK\*.

**Diagnosis.** Phyllobranchiate gills. Shield (Fig. 25a) as long as broad; dorsal surface weakly calcified medially; rostrum broadly rounded, with low dorsal ridge; anterior margins weakly concave; lateral projections subtriangular, terminating in small spine; ventrolateral margin with spine (not always visible in dorsal view); posterior margin broadly rounded. Ocular peduncles more than half length of shield; ocular acicles subtriangular, terminating in strong multifid spine; corneae slightly dilated. Maxillule with internal lobe of endopod bearing 4 long setae. Sternite of 3rd maxillipeds with small spine on each side of midline. Epistomial spine straight. Antennular peduncle exceeding distal margin of corneae by 0.75 length of ultimate segment. Antennal peduncle (Fig. 25b) reaching distal margin of cornea; 2nd segment with dorsolateral distal angle produced, terminating in strong simple spine reaching to midpoint of antennal acicle; acicles reaching distal margin of corneae, mesial margin with 9 to 14 spines; flagellum with short and long setae < 1 to 4 flagellar articles in length respectively. Chelipeds markedly dissimilar, with moderately dense setae. Right cheliped (Fig. 25d,e) with palm broader than long or about as broad as long in large specimens (SL ca 6.0 mm); fingers curved ventromesially, dactyl

with strongly concave and smooth ventromesial face; dorsal face of palm with scattered small spines or tubercles, ventral face smooth or with small tubercles; palm with dorsolateral and dorsomesial margins each well delimited by row of spines, ventromesial margin rounded, occasionally with row of 2 or 3 blunt spines proximally; carpus with numerous small spines or tubercles on dorsal surface, and well delimited dorsolateral margin with row of spines. Left cheliped (Fig. 25c) usually weakly calcified on lateral face of carpus; carpus with dorsal row of 4 to 6 small, well-spaced spines, and strong dorsodistal spine. Ambulatory legs (Fig. 25f,g) with dactyls having ventromesial row of 7 (3rd pereopod) to 15 (2nd pereopod) small, often minute corneous spines, and dorsal and dorsomesial rows of long setae; carpi each with dorsodistal spine; carpus of 2nd pereopod with dorsal row of 7 small spines. Anterior lobe of sternite of 3rd pereopods setose, armed with 1 spine. Fourth pereopod (Fig. 25h) with propodal rasp consisting of 1 row of ovate scales. Uropods and telson (Figs 25j, 26) markedly asymmetrical; telson lacking transverse suture separating anterior and posterior lobes; posterior lobes separated by shallow U-shaped median cleft, terminal margins armed with often long, curved corneous spines; in large females (SL > 6.0 mm) posterior lobes armed with several rows of corneous spines on distal margin, rows of spines often extending to dorsodistal surface (Fig. 26a). Males lacking 1st gonopods, with unpaired, uniramous 2nd left pleopod (Fig. 25i). Females with vestigial right 2nd pleopod.

**Habitat and symbiotic associations.** Found in gastropod shells.

**Distribution.** Western pacific: Philippines, China Sea, Indonesia, Japan, and now Australia. Depth: 161 to 558 m.

**Affinities.** *Paragiopagurus acutus* is most similar to *P. bicarinatus* and *P. hirsutus*. The former can be separated from *P. bicarinatus* by the shape and armature of the mesial face of the right palm. The mesial face of *P. acutus* is not expanded distally, and the ventromesial margin is rounded; the mesial face of *P. bicarinatus* is expanded distally, and the ventromesial margin is well delimited by a row of spines. *Paragiopagurus acutus* differs from *P. hirsutus* by the armature and setation of the right chela (see Affinities under *P. hirsutus*). Additionally, *P. acutus* reaches a much larger size than *P. bicarinatus* or *P. hirsutus*, and exhibits a stronger degree of sexual dimorphism in the telson (Fig. 26).

**Remarks.** De Saint Laurent (1972) provisionally proposed three subspecies, *Parapagurus acutus acutus*, *P. a. bicarinatus*, and *P. a. hirsutus*, for specimens that apparently could be differentiated only by the characteristics of the right cheliped. De Saint Laurent did observe that when all specimens of her subspecies were considered, a great range of variability occurred in the relative length of the ocular peduncles, ocular acicles, and the right cheliped. She proposed a subspecific division for the specimens rather than a specific one because of the impossibility she encountered in assigning specimens that were missing the right cheliped. Subsequently, Lemaitre (1989) transferred the subspecies of *P. acutus* to *Sympagurus* (sensu Lemaitre, 1989).

The study of numerous specimens deposited in various museums previously assigned to De Saint Laurent's (1972) three subspecies, and comparisons with recently collected Australian specimens, clearly show that they are sufficiently distinct morphologically to warrant elevation to specific status. Furthermore, their relatively broad sympatric distributions provides additional support for considering them as full species. The three species are quite similar in a number of characters such as the shape of the ocular acicles, left cheliped, telson, and absence of 1st pair of gonopods in males. However, as previously mentioned, they clearly differ by the shape and armature of the right cheliped.

*Paragiopagurus bicarinatus* (De Saint Laurent, 1972)

Fig. 27

*Parapagurus acutus bicarinatus* De Saint Laurent, 1972: 113 (type locality: Philippines, Albatross sta. 5289).  
*Sympagurus acutus bicarinatus*.—Lemaitre, 1989: 37.—Lemaitre, 1994: 412.

**Holotype.** Male (SL 5.6 mm), Philippines, southern Luzon, 5 mi (9.2 km) NW Matocot Point, Albatross sta. 5289, 13°41'50"N, 120°58'03"E, 315 m, 22 Jul 1908, USNM 168310.

**Australian material.** NORTHERN TERRITORY: 3 males (SL 4.8–5.8 mm), NW of Collier Bay, FRV *Soela*, 14°16.5'S, 122°36.6'E, 302 m, 14 Feb 1984, coll. S. Slack-Smith, WAM.

QUEENSLAND: 1 male (SL 4.1 mm), off Tully, 16°51.8'S, 147°08'E, epibenthic sledge, ORV *Franklin*, 500 m, 16 May 1986, coll. JCU, QM.

**Other material.** (For meaning of asterisks see Materials and Methods). SOUTH CHINA SEA: 2 males (SL 4.6, 5.2 mm), near Hong Kong, Albatross sta. 5313, 21°30'N, 116°43'E, 274 m, 4 Nov 1908, USNM 168982\*.

PHILIPPINES: 7 males (SL 3.1–4.9 mm), 1 female (SL 2.9 mm), Verde Is. Passage, off Matocot Point, Albatross sta. 5268, 13°42'N, 120°57'15"E, 311 m, 8 Jun 1908, USNM 168981\*. 1 male (SL 3.9 mm), between Leyte and Mindanao, off Botoselo Point, Albatross sta. 5486, 10°02'N, 125°19'20"E, 314 m, 22 Jul 1908, 1070 m, USNM 168983\*.

**Diagnosis.** Phyllobranchiate gills. Shield (Fig. 27a) as long as broad; dorsal surface weakly calcified medially; rostrum broadly rounded, with low dorsal ridge; anterior margins weakly concave; lateral projections subtriangular, terminating in small spine; ventrolateral margin with spine (not always visible in dorsal view); posterior margin broadly rounded. Ocular peduncles more than half length of shield; ocular acicles subtriangular, terminating in strong multifid spine; corneae slightly dilated. Maxillule with internal lobe of endopod bearing 4 long setae. Sternite of 3rd maxillipeds with small spine on each side of midline. Epistomial spine straight. Antennular peduncle exceeding distal margin of corneae by 0.75 length of ultimate segment. Antennal peduncle (Fig. 27b) reaching distal margin of cornea; 2nd segment with dorsolateral distal angle produced, terminating in strong simple spine reaching to midpoint of antennal acicle; acicles reaching distal margin of corneae, mesial margin with 10 to 13 spines; flagellum with short and long setae < 1 to 4 flagellar articles in length respectively. Chelipeds markedly dissimilar, with moderately dense setae. Right cheliped (Fig. 27d,e) with palm broader than long, fingers curved ventromesially, dactyl with concave ventromesial face; dorsal face of palm with numerous small spines or tubercles, ventral face smooth or with scattered small tubercles; palm with dorsolateral, dorsomesial, and ventromesial margins each well delimited by row of strong spines, and ventromesial face expanded distally; carpus with numerous small tubercles or spines on dorsal surface, and well delimited dorsolateral margin with row of spines. Left cheliped (Fig. 27d) with lateral face of carpus usually weakly calcified; carpus with dorsal row of 6 to 15 small spines, and strong dorsodistal spine. Ambulatory legs (Fig. 27f–h) with dactyls having ventromesial row of 3 or 4 small corneous

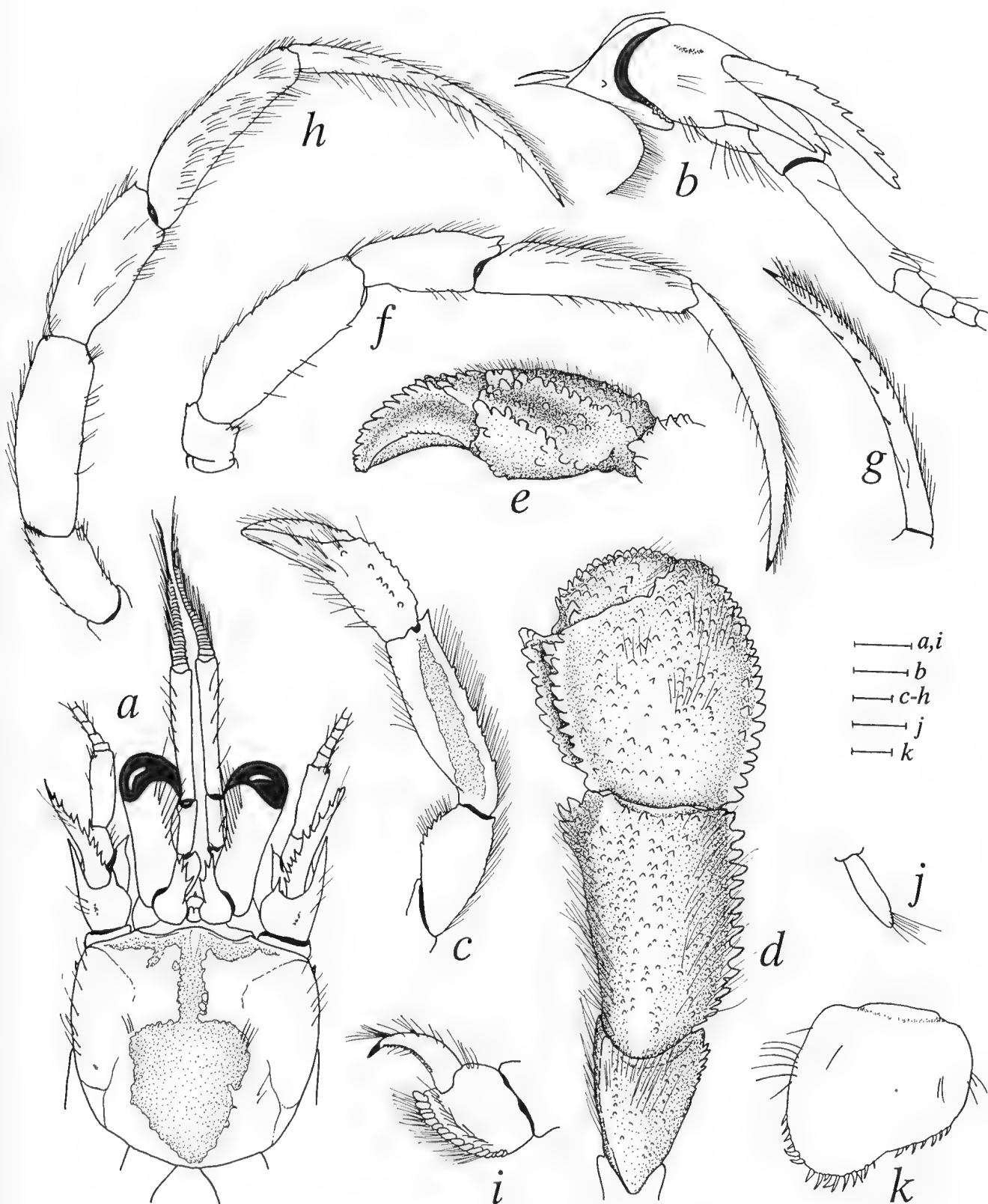


Fig. 27. *Paragiopagurus bicarinatus* (De Saint Laurent, 1972), male (SL 4.1 mm), Queensland, QM. a, shield and cephalic appendages; b, right antennal peduncle, lateral; c, left cheliped, dorsolateral; d, right cheliped; e, chela of same, mesial; f, right 2nd pereopod, lateral; g, dactyl of same, mesial; h, right 3rd pereopod, lateral; i, propodus and dactyl of left 4th pereopod, lateral; j, left 2nd pleopod, lateral; k, telson. Scales = 1 mm (a,c-h), and 0.5 mm (b,i-k).

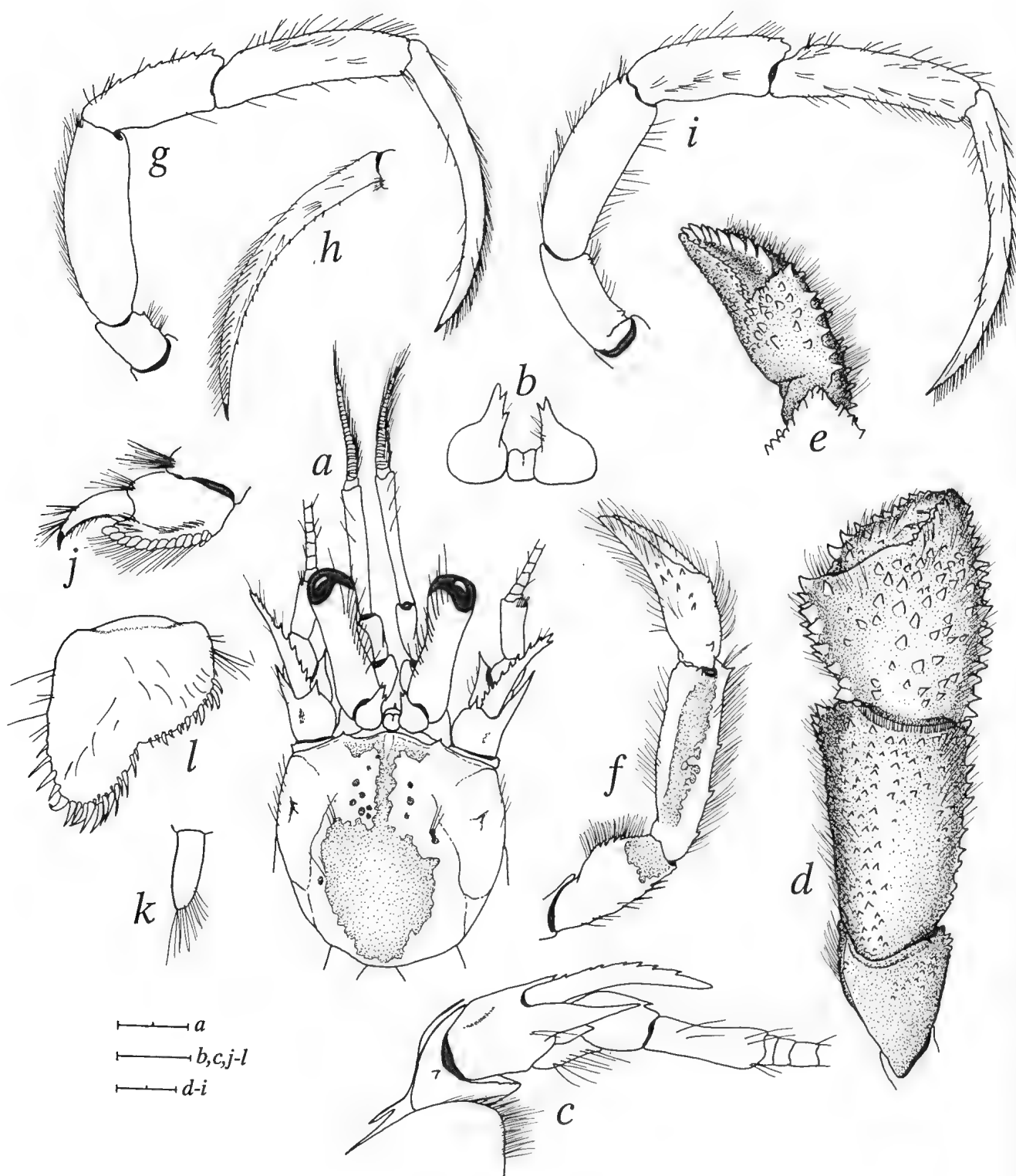


Fig. 28. *Paragiopagurus hirsutus* (De Saint Laurent, 1972), male (SL 6.1 mm), Queensland, QM. a, shield and cephalic appendages; b, ocular acicles, dorsal; c, right antennal peduncle, lateral; d, right cheliped (setae partially omitted); e, chela of same, mesial; f, left cheliped, dorsolateral (setae partially omitted); g, right 2nd pereopod, lateral; h, dactyl of same, mesial; i, right 3rd pereopod, lateral; j, propodus and dactyl of left 4th pereopod, lateral; k, left 2nd pleopod, lateral; l, telson. Scales = 2 mm (a), 1 mm (b,c,j-l), and 2 mm (d-i).

spines, and dorsal and dorsomesial rows of long setae; carpi each with small dorsodistal spine; carpus of 2nd pereopod with 2 small dorsal spines (spines sometimes obsolete). Anterior lobe of sternite of 3rd pereopods setose, armed with 1 marginal spine. Fourth pereopod (Fig. 27i) with propodal rasp consisting of 1 row of ovate scales. Uropods and telson (Fig. 27k) markedly asymmetrical; telson lacking transverse suture separating anterior and posterior lobes; posterior lobes separated by shallow U-shaped median cleft, terminal margins armed with often long, curved corneous spines. Males lacking 1st gonopods, with unpaired, uniramous 2nd left pleopod (Fig. 27j). Female with vestigial right 2nd pleopod.

**Habitat and symbiotic associations.** Found in gastropod shells.

**Distribution.** Western Pacific: Philippines, and Australia. Depth: 274 to 1070 m.

**Affinities.** *Paragiopagurus bicarinatus* closely resembles *P. acutus* and *P. hirsutus*. In the former, the mesial face of the right palm is expanded distally, and has a dorsomesial and a ventromesial row of spines. In both *P. acutus* and *P. hirsutus* the mesial face is not expanded distally, and the ventromesial face is rounded and lacks a row of spines.

**Remarks.** As previously mentioned, *Sympagurus acutus bicarinatus* (De Saint Laurent, 1972), is herein elevated to specific rank (see remarks under *Paragiopagurus acutus*).

### *Paragiopagurus hirsutus* (De Saint Laurent, 1972)

Fig. 28

*Parapagurus acutus hirsutus* De Saint Laurent, 1972: 113, fig. 19 (type locality: Japan, Tosa Bay).  
*Sympagurus acutus hirsutus*.—Lemaitre, 1989: 37.—Lemaitre, 1994: 412.

**Holotype.** Male, Japan, Tosa Bay, Nov 1963, coll. K. Sakai (not seen).

**Australian material.** WESTERN AUSTRALIA: 1 male (SL 5.0 mm), NW of Collier Bay, FRV *Soela*, 14°16.5'S, 122°36.6'E, 302 m, 14 Feb 1984, coll. S. Slack-Smith, WAM.

QUEENSLAND: 2 males (SL 4.0, 6.1 mm), 1 female ovig. (SL 3.6 mm), off Tully, 16°51.8'S, 147°08'E, epibenthic sledge, ORV *Franklin*, 500 m, 16 May 1986, coll. JCU, QM. 1 female (SL 4.1 mm), 1 female ovig. (SL 4.0 mm), off Tully, 17°51.3'S, 147°07.8'E, trawled, ORV *Franklin*, 505 m, 17 May 1986, coll. JCU, QM.

**Other material.** (For meaning of asterisks see Materials and Methods). SOUTHWESTERN INDIAN OCEAN?: 1 female (SL 5.6 mm), off Durban, 73 m, NMV J16205 (see remarks).

SOUTH CHINA SEA: 2 (dismembered, sex indet.), near Hong Kong, *Albatross*, sta. 5314, 21°41'N, 116°46'E, 223 m, 5 Nov 1908, USNM 168988\*. 7 males (SL 4.4–6.3 mm), near Hong Kong, *Albatross*, sta. 5313, 21°30'N, 116°43'E, 274 m, 4 Nov 1908, USNM 168987\*.

PHILIPPINES: 4 males (SL 6.8–7.2 mm), 1 female (SL 5.7 mm), N Luzon, off Hermanas Is., *Albatross*, sta. 5325, 18°34'15"N, 121°51'15"E, 410 m, 12 Nov 1908, USNM 168989\*. 2 males (SL 4.0, 5.8 mm), Verde Is. Passage, off Matocot Point, *Albatross*, sta. 5268, 13°42'N, 120°57'E, 311 m, 8 Jun 1908, USNM 168984\*. 3 males (SL 4.7–5.3 mm), 3 females (SL 4.8–5.8 mm), 2 (dismembered, sex indet.), Verde Is. Passage, off Matocot Point, *Albatross*, sta. 5289, 13°41'50"N, 120°58'30"E, 315 m, 22 Jul 1908, USNM 168985\*. 1 male (SL 5.4 mm), Verde Is. Passage, off Matocot Point, *Albatross*, sta. 5297, 13°41'20"N, 120°58'E, 362 m, 24 Jul 1908, USNM 168986\*.

NEW ZEALAND: 1 female ovig. (SL 8.8 mm), Wanganella Bank, Norfolk Ridge, E slope, RV *Tangaroa*, NZOI sta. 0.634, BS 888, 32°40.2'S, 167°39.0'E, 487–357 m, 29 Jan 1981, NMNZ Cr 8459.

**Diagnosis.** Phyllobranchiate gills. Shield (Fig. 28a) as long as broad; dorsal surface weakly calcified medially; rostrum broadly rounded, with low dorsal ridge; anterior margins weakly concave; lateral projections subtriangular, terminating in small spine; ventrolateral margin with spine (not always visible in dorsal view); posterior margin broadly rounded. Ocular peduncles more than half length of shield; ocular acicles (Fig. 28b) subtriangular, terminating in strong multifid spine (rarely simple on one side); corneae slightly dilated. Maxillule with internal lobe of endopod bearing 3 or 4 long setae. Sternite of 3rd maxillipeds with small spine on each side of midline. Epistomial spine straight, frequently bifid. Antennular peduncle exceeding distal margin of corneae by 0.75 length of ultimate segment. Antennal peduncle (Fig. 28c) reaching distal margin of cornea; 2nd segment with dorsolateral distal angle produced, terminating in strong simple spine reaching to midpoint of antennal acicle; acicles reaching distal margin of corneae, mesial margin with 8 to 13 spines; flagellum with long setae 3 or 4 flagellar articles in length. Chelipeds markedly dissimilar, surfaces with moderately dense setae interspersed with numerous long, stiff setae (shown partially in Fig. 28f,d). Right cheliped (Fig. 28d) with palm broader than long, fingers curved ventromesially, dactyl with longitudinal row of blunt spines on ventral face; dorsal face of palm with strong spines (at least proximomedially), ventral face with numerous tubercles; palm with dorsolateral and dorsomesial margins each well delimited by row of strong spines, and ventromesial face rounded; carpus with numerous small tubercles or spines on dorsal surface. Left cheliped (Fig. 28f) with lateral face of carpus usually weakly calcified; with dorsal row of 2 to 6 small, well-spaced spines, and strong dorsodistal spine on carpus. Ambulatory legs (Fig. 28g–i) with dactyls having ventromesial row of 8 to 13 corneous



spines, and dorsal and dorsomesial rows of long setae; carpi each with small dorsodistal spine; carpus of 2nd pereopod with dorsal margin armed with 1 to 4 small spines. Anterior lobe of sternite of 3rd pereopods setose, armed with 1 or 2 marginal spines. Fourth pereopod (Fig. 28j) with propodal rasp consisting of 1 row of ovate scales. Uropods and telson (Fig. 28l) markedly asymmetrical; telson lacking transverse suture separating anterior and posterior lobes; posterior lobes separated by U-shaped median cleft, terminal margins armed with often long, curved corneous spines. Males lacking 1st gonopods, with unpaired, uniramous 2nd left pleopod (Fig. 28k). Females with vestigial right 2nd pleopod.

**Habitat and symbiotic associations.** Inhabits gastropod shells.

**Distribution.** Indo Pacific: China Sea; Philippines; Australia; New Zealand; questionably from off Durban, South Africa (see remarks). Depth: 223 to 505 m.

**Affinities.** *Paragiopagurus hirsutus* resembles *P. acutus* and *P. bicarinatus*, but can easily be differentiated from those two species by armature and setation of the right chela. In *P. hirsutus* the spines on the dorsal surface of the chela are distinctly stronger and sharper than in *P. acutus* and *P. bicarinatus*; the surface of the right chela has numerous long, stiff setae, whereas those of *P. acutus* and *P. bicarinatus* do not.

**Remarks.** As previously mentioned, *Sympagurus acutus hirsutus* (De Saint Laurent, 1972) is herein elevated to specific rank (see remarks under *Paragiopagurus acutus*).

A single specimen (NMV J16205) of *Paragiopagurus hirsutus* presumably from off Durban, South Africa, in the western Indian Ocean, was examined. No data is available on when or how this specimen was obtained and deposited in NMV (G.C.B. Poore, pers. comm.). Although this species has not been previously collected outside the western Pacific, it is conceivable that its distribution may include the Indian Ocean. However, until more specimens are found that would confirm such a distribution, the presence of this species in the western Indian Ocean is considered questionable.

### *Paragiopagurus boletifer* (De Saint Laurent, 1972)

*Paragiopagurus boletifer* De Saint Laurent, 1972: 110, figs 5, 20 (type locality: Japan, Tosa Bay).—Miyake, 1978: 72.—Miyake, 1982: 120, pl. 40, fig. 4.—Baba *et al.*, 1986: 196, fig. 144.

*Sympagurus boletifer*.—Lemaitre, 1989: 37.—Lemaitre, 1994: 382, figs 5,6, 27a,b, 28b,c.—Poupin, 1994: 51.

**Holotype.** Male (SL 8.0 mm), Japan, Tosa Bay, 250–300 m, 1963, coll. K. Sakai, MNHN Pg2230.

**Australian material.** 1 male (SL 5.2 mm), Britannia Sea Mount, Western Tasman Sea, ORV *Franklin*, sta. 0589–47, 28°17.47'S, 158°37.89'E, 419 m, 10 May 1989, colls. J.K. Lowry *et al.*, AM P39447.

**Diagnosis.** Phyllobranchiate or intermediate gills. Shield as long as broad; dorsal surface usually weakly calcified on half or more of surface; rostrum broadly rounded, with low dorsal ridge; anterior margins straight; lateral projections broadly subtriangular, terminating in spine; posterior margin broadly rounded. Ocular peduncles more than half length of shield; ocular acicles subtriangular, terminating in strong spine; corneae slightly dilated. Sternite of third maxillipeds with small spine on each side of midline. Epistomial spine short, straight. Antennular peduncle exceeding distal margin of corneae by length of penultimate segment. Antennal peduncle at most reaching distal margin of cornea; 3rd segment with strong ventromesial distal spine; 2nd segment with dorsolateral distal angle produced, terminating in multifid spine (occasionally with additional small spine dorsally); acicles reaching distal margin of corneae, mesial margin armed with 11 to 14 spines; flagellum with setae arranged in series of long (4–8 articles in length) and short (about 1 article in length) setae about every 15–20 articles. Chelipeds strongly dissimilar. Right cheliped massive, operculate; chela about as broad as long, dorsal surface covered with numerous spines and dense plumose setae (especially on distal half and fingers); fingers curved ventromesially; ventral face of palm and fingers covered with numerous mushroom-like tubercles; palm with dorsolateral margin well delimited by row of spines; carpus with numerous small tubercles or spines on dorsal surface. Left cheliped usually well calcified; palm with dorsomesial row of small tubercles; carpus with dorsodistal spine. Ambulatory legs reaching to tip of extended right cheliped; dactyl about twice as long as propodus, with ventromesial row of about 12 corneous spines, and dorsal and dorsomesial rows of long bristle-like setae; carpus with small dorsodistal spine. Anterior lobe of sternite of 3rd pereopods armed with marginal spine. Fourth pereopod with dactyl terminating in corneous claw (more slender and longer in females than in males); propodal rasp consisting of 1 row of ovate scales. Telson and uropods strongly asymmetrical; telson with weak transverse suture separating anterior and posterior lobes; posterior lobes separated by V-shaped median cleft, terminal margins armed with corneous spines (often strongly curved on left lobe). Male 1st gonopods with concave distal lobe; 2nd gonopods each with distal segment nearly flat. Female with vestigial right second pleopod.

**Colour.** Shield cream yellow tinged with orange. Ocular peduncles, antennular and antennal peduncles pale yellow; antennular flagella pale purple. Left cheliped and second to fifth pereopods uniformly pale purple. Chela and carpus of right cheliped with dorsal and ventral surface orange-reddish, with white mushroom-



like tubercles or spines; merus whitish with tinge of pale orange distally (Lemaitre, 1994: 384).

**Distribution.** Indo Pacific: Comoro Islands; Japan; Australia; Hawaii; and French Polynesia. Depth: 85 to 419 m.

*Paragiopagurus ruticheles* (A. Milne Edwards, 1891)

*Eupagurus ruticheles* A. Milne Edwards, 1891: 133 (type locality: near Graciosa, Azores, *L'Hirondelle*, sta. 234, 39°01'40"N, 30°15'40"W, 454 m).

*Parapagurus ruticheles*.—De Saint Laurent, 1972: 112.

*Sympagurus ruticheles*.—Lemaitre, 1989: 37.—Lemaitre, 1990: 235, figs 11, 12.—Lemaitre, 1994: 412.

**Type material.** SYNTYPES: 2 males (SL 3.6–5.9 mm), 1 female ovig. (SL 3.2 mm), near Graciosa, Azores [Atlantic Ocean], *L'Hirondelle*, sta. 234, 39°01'40"N, 30°15'40"W, 454 m, 19 Aug 1888, MO.

**Australian material.** 1 male (SL 3.8 mm), Britannia Sea Mount, Western Tasman Sea, ORV *Franklin*, sta. 0589–47, 28°17.47'S, 158°37.89'E, 419 m, 10 May 1989, colls. J.K. Lowry *et al.*, AM P44473

**Diagnosis.** Phyllobranchiate gills. Shield about as broad as long, dorsal surface usually weakly calcified medially; rostrum broadly rounded, with short dorsal ridge; lateral projections subtriangular, with small terminal spine; ventrolateral margin with small spine (often lacking on one side). Ocular peduncles more than half length of shield; acicles terminating in strong spine; corneae dilated. Antennular peduncles exceeding distal margin of corneae by slightly less than length of ultimate segment. Antennal peduncles not exceeding distal margin of corneae; acicles not exceeding distal margin of corneae, mesial margin armed with 7 to 14 spines. Sternite of 3rd maxilliped with spine on each side of midline. Epistomial spine straight, occasionally bifid. Right cheliped elongate, with transverse furrows on ventral surfaces of chela and ventrolateral face of carpus; palm with well delimited dorsomesial, ventromesial and dorsolateral margins each armed with spines (usually having corneous tips), and concave mesial face often expanded distally; carpus with well delimited dorsolateral margin armed with corneous-tipped spines. Left cheliped weakly calcified on merus and carpus; unarmed except for scattered small spines on dorsal surface of palm and dorsal margin of carpus. Ambulatory legs with dactyls each having dorsal and distal dorsomesial row of setae, and ventromesial row of about 13 spinules; merus of right 3rd pereopod usually with dorsal row of small spines. Anterior lobe of sternite of 3rd pereopods unarmed. Fourth pereopod with strongly curved dactyl;

propodal rasp consisting of 1 row of ovate scales. Uropods and telson strongly asymmetrical; telson with transverse suture separating anterior and posterior lobes; posterior lobes separated by shallow median cleft, terminal margins armed with strong often curved corneous spines. Males lacking 1st pleopods; with unpaired, uniramous 2nd left pleopod. Females with unpaired left 2nd pleopod (lacking right vestigial 2nd pleopod).

**Distribution.** Central and western Pacific: Hawaiian Islands; and Australia. Eastern Atlantic: Portugal to Senegal. Depth: 200 to 1440 m.

### Distribution

With our still limited knowledge of the parapagurid fauna from many areas of the Pacific and Indian Oceans, it is difficult to generalise as to the distributional patterns of species or groups of species. In Australia, parapagurids from the western, northern and southeastern shelf, and continental slope areas, now seem reasonably well sampled. However, those from the southern region, in particular the Great Australian Bight, still remain to be studied.

Of the 18 species treated in this study, eight are broadly distributed in the Indo Pacific region, and are found from the western Indian Ocean, to at least as far east as Australia, *Sympagurus brevipes*, *S. papposus* n.sp., *S. trispinosus*, *Oncopagurus indicus*, *O. monstrosus*, *O. minutus*, *Paragiopagurus hirsutus*, and *P. boletifer*. Three of these eight are known to occur further to the east, *Paragiopagurus hirsutus*, in New Zealand, and *P. boletifer* and *S. trispinosus*, in French Polynesia. Of the species that occur in Australia, five are distributed exclusively in the western Pacific, *Strobopagurus sibogae*, *Sympagurus planimanus*, *P. acutus*, *P. bicarinatus*, and *P. diogenes*; five occur also in Japan, *Strobopagurus sibogae*, *O. monstrosus*, *P. acutus*, *P. diogenes*, and *P. boletifer*; and one in Hawaii, *P. boletifer*. One species, *Sympagurus dimorphus*, is distributed only in the cold-temperate regions of the southern hemisphere (south of 22°S, but in the Atlantic possibly as far north as 9°S). Of the new species discovered during this study, three have so far been found only in Australia, *S. soela* n.sp. and *O. cidaris* n.sp., from Queensland and New South Wales; and *S. villosus* n.sp., from Queensland. One species, *P. ruticheles*, has a broad, disjunct distribution, known from elsewhere in the Pacific only from Hawaii, but also occurs in the eastern Atlantic. Only two species, *S. dimorphus* and *P. hirsutus*, are so far known from New Zealand.

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## A Review of the Genus *Pedrocortesella* Hammer in Australia (Acarina: Cryptostigmata: Pedrocortesellidae)

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**ABSTRACT.** The paper reviews the genus *Pedrocortesella* Hammer in Australia and a rediagnosis is given for the genus. *Pedrocortesella propinqua* P. Balogh and *P. temperata* P. Balogh are redescribed and adults of 17 new species are described: *P. anica*, *P. augusta*, *P. bannisteri*, *P. bithongabela*, *P. callitarsus*, *P. calmorum*, *P. conundrum*, *P. enigma*, *P. gunjina*, *P. hangayi*, *P. impedita*, *P. kanangra*, *P. leei*, *P. nortoni*, *P. obesa*, *P. subula*, and *P. truncata*. *Pedrocortesella conundrum* and *P. kanangra* are regarded as *incertae sedis*. *Acupedicellus* Hunt & Lee, 1995 becomes a junior synonym of *Pedrocortesella* and a new combination is established for its type species: *Pedrocortesella cornuta* (Hunt & Lee, 1995). *Pedrocortesella dispersa* P. Balogh and *P. queenslandica* P. Balogh are assigned to different genera in other papers. A key is given to adults of the 22 Australian *Pedrocortesella* species currently recognised. Characters of systematic value are examined. Five possible species groups are discussed. The World distribution of the genus is briefly discussed and relevant literature cited.

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The mite superfamily Plateremaeoidea (*sensu* Marshall *et al.* (1987)) is an important component of the oribatid fauna of Australian soils and arboreal habitats (Hunt, 1994; Hunt & Lee, 1995; Walter, 1995). *Pedrocortesella* Hammer is currently the most speciose genus in the superfamily in Australia. The other species-rich plateremaeoid genus, *Pheroliodes* Grandjean, will be reviewed elsewhere (Hunt, 1996a), as will some less species-rich, largely arboreal taxa (Hunt, 1996b; 1996c).

Species in the genus have an essentially Gondwanan distribution with extensions into Japan and the eastern Palearctic. Four species have been described from South America (Hammer, 1961; Fernandez, 1990; Eguaras *et al.*, 1990) including the type species *Pedrocortesella pulchra* Hammer; one from New Zealand (Hammer, 1966; Paschoal, 1987b); two from New Guinea (J. Balogh, 1968; 1970); four from Africa (Pletzen, 1963; J. Balogh, 1966; P. Balogh, 1985), four from Japan (Aoki, 1984; Aoki & Suzuki, 1970; Hunt, 1996b) and eight from the eastern Palearctic (J. Balogh & Mahunka,

1965; Aoki, 1974; Golosova, 1980; Grishina, 1981; Ryabinin, 1986). This list includes species originally placed in *Pedrocortesella* Hammer (J. Balogh & Mahunka, 1965; J. Balogh, 1966; 1970; Aoki, 1974; 1984; Grishina, 1981; Ryabinin, 1986) but probably belonging in *Pedrocortesella* or at least closely allied taxa (Paschoal, 1987a regards many as *incertae sedis*).

In other papers in this series, *Pedrocortesella dispersa* P. Balogh is placed in *Hexachaetoniella* Paschoal (Hunt, 1996b) and *P. queenslandica* P. Balogh is placed in combination with a new genus, *Labiogena* (described in this volume; see Hunt, 1996c).

Aside from an Eocene fossil record possibly of the genus (O'Dowd *et al.*, 1991), 22 *Pedrocortesella* species from Australia are recognised in this work, doubling the number of species in the genus. It is probable, however, that many new species remain to be discovered in other biogeographical regions, particularly if drier habitats are sampled more intensively.

Recent debate over the separate generic status of *Pedrocortesella* is reviewed by Hunt & Lee (1995) who list its differences from *Pheroliodes*, namely: enantiophyses and seta *ex* absent on prodorsum, two pairs of anal setae, presence of a concave area on the notogaster, and a different placement of some notogastral setae. It is possible, however, that a phylogenetic analysis will reveal that *Pedrocortesella* is not monophyletic.

Debate also exists over the family placement of *Pedrocortesella*. This is polarised around the highly split classification of Paschoal (1989) in which there is a proliferation of family level taxa, and the highly lumped classification of Woas (1992). In the latter, a single family accommodates all genera in the Plateremaeoidea *sensu* Marshall *et al.* (1987), that is all genera in the Plateremaeoidea+Gymnodamaeidea of Paschoal (1989). A thorough phylogenetic analysis is needed to help resolve the higher classification.

To avoid confusing matters further, I am following Balogh & Balogh (1992) who provide the most recent world overview of oribatid mites. These authors follow Paschoal (1987b, 1989) in placing *Pedrocortesella* in the Pedrocortesellidae Paschoal.

### Methods and Materials

Descriptions are arranged in alphabetical order and apply to adults only. A Cambridge Stereoscan 120 with Robinson Detector was used for scanning electron microscopy. The holotype of the type species and holotypes of Hammer's New Zealand species and P. Balogh's Australian species have been examined. The following abbreviations are used to indicate the present location of material: AM—Australian Museum, Sydney; ANIC—Australian National Insect Collection, Canberra; CNC—Canadian National Collections of Insects, Arachnids and Nematodes, Ottawa; ELU—Zoosystematical and Ecological Institute, Eotvos Lorand University, Budapest; FMNH—Field Museum of Natural History, Chicago; QM—Queensland Museum, Brisbane; SAMA—South Australian Museum, Adelaide; WAM—Western Australian Museum, Perth; ZMK—Zoologisk Museum, Copenhagen. CALM in collection data is an acronym for Department of Conservation and Land Management, Western Australia.

Specimens are preserved in alcohol unless otherwise stated. Reference to the colloquial term "berlesates" in species data denotes the numbered series of Berlese or Tullgren funnel residues housed by some institutions.

Many structures referred to in descriptions and the key are illustrated with their abbreviations in Figure 1. For clarity, some notogastral setae are selectively labelled in the figures. Measurements are in micrometers and ratios of notogaster length to width in descriptions are given in the actual measures, e.g., 540:460, for each specimen measured. "SEM stub numbers" refer to sequentially numbered stubs on which specimens have been mounted for scanning electron microscopy (SEM). The abbreviation "ill." means the specimen was used in illustrations.

### Setal Notation

The system of notogastral setal notation that is used in this work is modified from that used by Grandjean (1964) for *Pheroliodes wehncke* Grandjean. He uses *hl*,

*p1*, *p2* and *p3* where homologies with particular setae of primitive oribatids can be reasonably inferred; he uses *lp* (lateral posterior) for the remaining seta in *Ph. wehncke* as its homology cannot be inferred with the same level of confidence (Fig. 1C). The same notation for these setae can be applied to *Pedrocortesella conundrum* n.sp. In other *Pedrocortesella* species, however, homology of only *hl* and *p1* can be inferred with confidence (Fig. 1A,D); a less certain terminology of *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* is used for the remaining three pairs to indicate possible homology with setae in *Pheroliodes* and *Pe. conundrum*. If there are six pairs of notogastral setae, *lm* (lateral median) is used here for the most anterior pair (Fig. 1A).

The system of setal notation for appendages follows Grandjean (1964) which is explained by Norton (1977), and gnathosomal terminology follows Hammen (1967). The format of reporting genitoanal chaetotaxy is based on Paschoal (1987b) in his revision of *Pedrocortesella*, namely 6-7:1:2(rarely 3):2-3 which means 6-7 genital setae, 1 aggenital seta, 2(rarely 3) anal setae and 2-3 adanal setae.

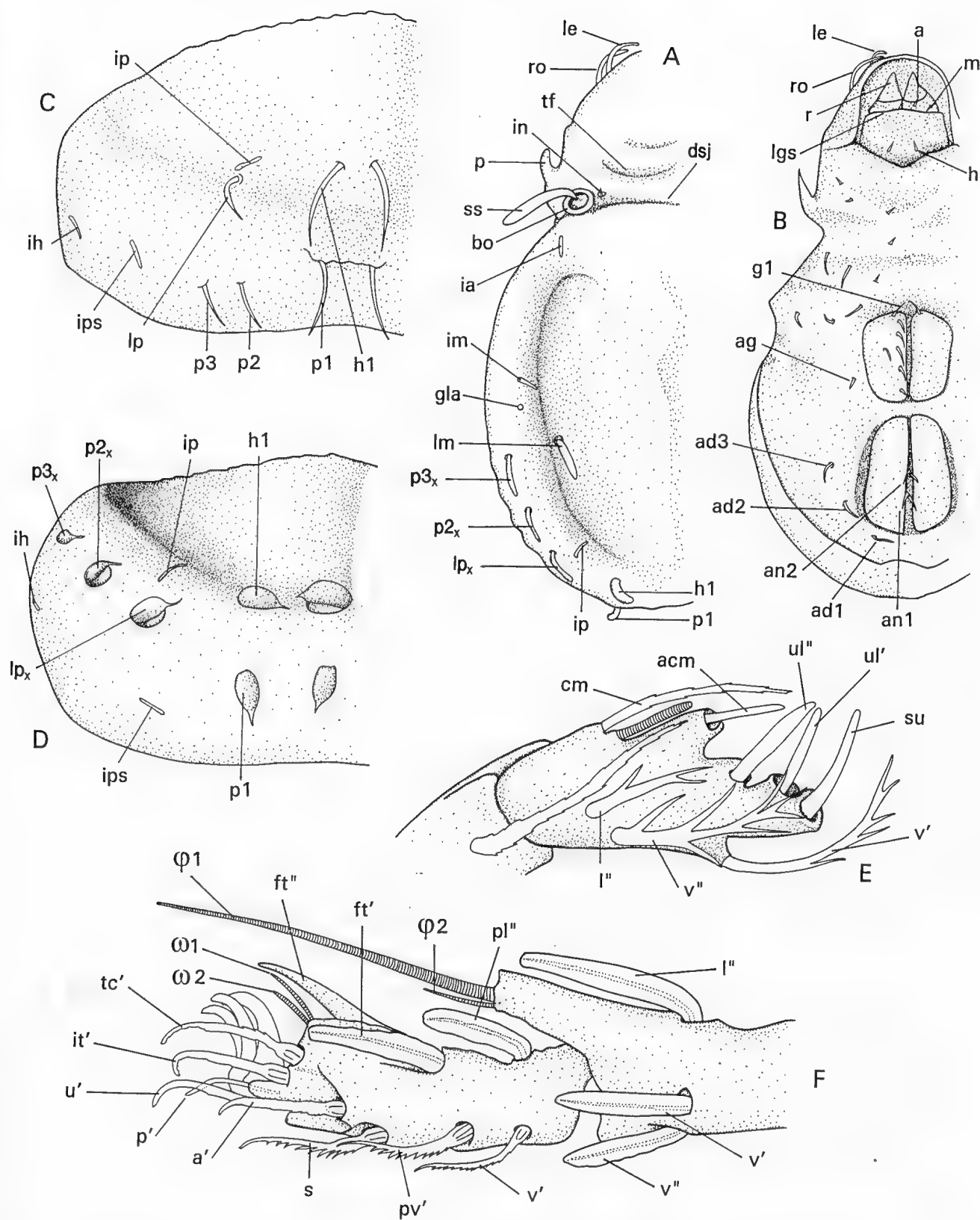
Terms used for integumental sculpturing are discussed under "Character Descriptions" below.

### Character Descriptions

**Integumental characters.** *Body:* Like many plateremaeoid genera, *Pedrocortesella* has an intricately ornamented integument which may be foveate (with more or less circular pits having flat or gently sloping floors) (Fig. 39B), alveolate (wide polygonal pits separated from adjacent pits by narrow walls) (Fig. 11A) or punctate (perforated by narrow pits with steep sides and no obvious floors) (Fig. 37A). Small foveae (foveolae) may grade into punctations. The walls separating pits may unite into a net-like or reticulate appearance (Fig. 11A), hence the term "reticulate-alveolate". The pattern on the notogaster is usually less developed in adults of species carrying exuvial scalps. In some species, the central part of the notogaster may have an irregular pattern of ridges and depressions though the basic reticulate-alveolate structure is frequently preserved on the margins and flanks. In some species, floors of foveae may be perforated by a visible pore (Fig. 39B). Punctations described for some species may prove to be these pores without the surrounding foveae. The fine structure of the integument is very useful in distinguishing species. The nominal species, *P. dispersa*, has foveae with a central raised mound of integument which seems to be a diagnostic character helping to define *Hexachaetoniella* (Hunt, 1996b).

**Leg integument.** The reticulate pattern of the leg integument varies according to species and where possible is illustrated for tarsus I in the descriptions below. The underlying reticulate pattern of the integument in *Pedrocortesella* is accentuated by the secreted cerotegument which caps it. In *Pheroliodes*, however, the cerotegument is typically distributed as separate tubercles.

**Cerotegument.** The entire integument is covered by a layer of secretion called cerotegument which tends to reflect the topography of the underlying surface. Fig. 46D illustrates



**Fig. 1.** Some structures of descriptive value. A = dorsum of *Pedrocortesella augusta* n.sp. (integumental sculpturing not shown), B = venter of *P. temperata* (integumental sculpturing not shown); C,D = posterior aspect of *Pheroliodes roblensis* (after Covarrubias (1968) and *Pedrocortesella leei* n.sp. (integumental sculpturing not shown); E = tarsus of pedipalp, antiaxial (system of notation after Grandjean, solenidion shown as striped); F = Tibia (distal) and tarsus of leg I, paraxial (system of notation after Grandjean, solenidia shown as striped). Other abbreviations: dsj = dorsosejugal suture; ro, le, in = rostral, lamellar and interlamellar setae; p = pedotectal tooth; ss = sensillus; bo = bothridium; tf = transverse furrow; ia, im, ip = anterior, median and posterior furrows; ips = lateral posterior fissura; gla = pore of opisthosomal gland; h1, p1, p2, p3, p2x, p3x, lp, lm = notogastral setae (see Methods); lgs = labiogenal suture; h = seta on mentum; a, m = setae on gena; r = rutellum; g1 = first genital seta; ag = aggenital seta; anl = first adanal seta; ad1 = first adanal seta. Setae on epimera I-IV shown but not labelled.



cerotegument peeled back to expose the underlying integument. Raised structures like walls between foveae usually have raised stellate deposits of cerotegument (Fig. 39B) which may coalesce into crests (Fig. 39I); raised deposits occur less frequently on the floors of foveae. The manner of cerotegumental coating of setae on the body and legs is often species specific (e.g., Figs 5D and 7B).

**Exuvial scalps.** Notogastral exuviae are carried by immatures and also habitually by adults of two Australian species: *P. temperata* P. Balogh (Fig. 43A) and *P. cryptoreticulata* Hunt & Lee.

**Bothridium.** In *Pedrocortesella*, the bothridium abuts the notogaster somewhat more closely than in *Pheroliodes*. Consequently, the posterior wall of the bothridium is largely missing in some species. The shape of the bothridium is useful in separating some species.

**Sensillus.** In *Pedrocortesella*, the sensillus nearly always has the form of a petiolate, tuberculate blade with a rounded distal margin (Fig. 39D). The blade is generally broader than in *Pheroliodes* (Hunt, 1996a). Only two species placed in *Pedrocortesella*, *P. nortoni* n.sp. and *P. enigma* n.sp., have an ovoid, clavate sensillus (Fig. 34E). Other species with an ovoid sensillus, including the nominal *P. dispersa* and *P. queenslandica*, are referable to different genera (Hunt, 1996b; 1996c). *Pedrocortesella truncata* n.sp. has an apparently uniquely truncate sensillus with a reticulate, not tuberculate, surface.

**Rostral setae (ro) and lamellar setae (le).** In most plateremaeoids, setae *le* are well anterior to setae *ro*, an atypical condition for oribatids. The relative separation of *le*, that is how dorsally they are set, can be a specific character (cf., Figs 14E and 31B).

**Interlamellar setae (in).** Each is placed on an apophysis close to the mesad wall of the bothridium and usually at the edge of the dorsosejugal suture (Fig. 1A). Their precise location is a specific character. In *Labiogena*, they are generally situated further from the bothridium than in *Pedrocortesella* (Hunt, 1996c).

**Setae ex.** These are absent in *Pedrocortesella* but one pair of exobothridial setae occurs in *Pheroliodes*.

**Pedotectal tooth (p).** This is present in nearly all plateremaeoid taxa. In *Pedrocortesella* it is a conical structure which may vary according to species. Its apex lies close to trochanter 1. The tooth may limit the posterad movement of leg I, and in some species seems to engage a cavity in the trochanter.

**Median transverse furrow.** A deep transverse furrow separates the bothridial region from the remainder of the prodorsum and may represent the division between the two prodorsal tagmata. Unlike *Pheroliodes*, there are no enantiophyses (opposing horns) on either side of the furrow, nor a prominent transverse bar immediately anterior to it. The furrow is barely visible in some taxa related to *Pedrocortesella* (Hunt, 1996c).

**Carinae.** The prodorsum is marked with crests,

particularly in the bothridial region. These were described by Paschoal (1987b) as "apodemes". They are visible in the scanning electron micrographs but are not specifically described here, except for a transverse carina between setae *ro* and *le* which occurs in some species. No costulae are present as the carinae are not associated with the lamellar setae.

**Intramarginal depression.** The notogaster appears flattish in lateral view (Fig. 34B) but is actually depressed in a roughly U- or O-shaped region inside the margin; the notogastral margin and the central area tend to be convex while the area between is concave (Fig. 34A). The shape of the depression varies according to species. A more uniformly convex notogaster occurs in *Pheroliodes*.

**Fissurae (lyrifissurae).** Three pairs of large slits occur dorsally on the notogaster and from anterior to posterior are called fissurae *ia*, *im* and *ip* (Fig. 1A). Their orientation and length are thought to be species characters, though orientation can be quite variable. The scanning electron micrographs showing detail of the integument normally include fissura *im* (e.g., Fig. 22C). Fissurae on the lateral margin and venter are not described here.

**Number of notogastral setae.** In adults of most plateremaeoid taxa, the notogastral setae lie posterior to fissura *im* and are confined to the posterolateral and posterior margins and flanks. In *Pedrocortesella* and close relatives there are usually five pairs of notogastral setae, and less commonly six pairs.

**Position of notogastral setae.** In *Pheroliodes*, all five pairs of setae lie posterior to fissura *ip* (Fig. 1C). In species of *Pedrocortesella* with five pairs of setae, one pair (*h1*) is situated mid-posteriorly on or near the notogastral margin (Fig. 1D); another pair (*p1*) lies ventral to *h1* on the posterior flank; three pairs lie just inside or on the posterolateral margin, one usually posterior to fissura *ip*, two usually anterior to *ip* (Figs 1D, 31A,B). This condition appears to have involved the migration of setae *p2* and *p3* from their nymphal position on the posterior flank.

Five Australian species have six pairs of setae. Three species referable to *Hexachaetoniella* (see Hunt, 1996b), including *H. dispersa* (P. Balogh), have a broad leaf-like seta closely mesad of each fissura *im*. *Pedrocortesella augusta* n.sp. has a sixth seta lying well inside the lateral margin, mesad to the most anterior marginal seta, well posterad to fissura *im* and the opisthosomal gland opening *gla* (Fig. 1A). *Pedrocortesella kanangra* n.sp. has its additional seta in file with other posterolateral setae (Fig. 20F). *Pedrocortesella conundrum* has its sixth (most anterior) seta well inside the lateral margin, with the other setae distributed on the posterolateral flank.

The position of the sixth seta in plateremaeoids is variable and presence of the seta alone is not a generic character. However, in Australian species being referred by Hunt (1996b) to *Hexachaetoniella*, the sixth seta corresponds in position to that in the type species, *H. sexpilosa* (Hammer). Its position is regarded as a diagnostic character for that genus.

No consistent terminology of notogastral setae in *Pedrocortesella* presently exists. Aoki & Suzuki (1970,

fig. 1) use a notation that assumes homologies with setae in primitive oribatid mites are known, whilst Paschoal (1987b), Eguaras *et al.* (1990, fig. 1), Fernandez (1990, fig. 1) and Hunt & Lee (1995, fig. 6C) use notations where only some homologies are established. Additionally, these authors use differing notations for particular setae. Paschoal's interpretation of setal homology is preferred but uncertain homology with setae in *Pheroliodes* (Fig. 1C), as described by Grandjean (1964), is indicated by using  $lp_x$ ,  $p2_x$  and  $p3_x$  (see Methods, and Fig. 1).

**Form of notogastral setae.** Size and apparent shape can vary according to species or population (cf. Figs 41E and 16D, and Figs 41F and 41G). Apparent shape in scanning electron micrographs is strongly influenced by enveloping cerotegument; for example a setiform seta can appear leaf-shaped in scanning electron micrographs because of surrounding cerotegument.

**Caudal notch and carina.** A caudal concavity or notch visible from above under a dissecting microscope may be present in some species, particularly those from Western Australia (Fig. 16D). A caudal carina between setae  $p1$  occurs in some species (Fig. 2G).

**Gnathosoma.** Although not frequently studied, the gnathosoma provides some characters useful at species or higher levels. *Pedrocortesella* lacks a mental tectum except for a small tectum present in *P. nortoni*. *Labiogena* has a well-developed mental tectum (Hunt, 1996c).

On the pedipalp tarsus the presence or length of barbs on seta  $l''$ , the relative length of the apophysis supporting the eupathidial seta  $acm$  and the length of the solenidion are useful at the species and/or genus levels.

The chelicera has shelf-like processes antiaxially and paraxially near the ventral surface of the movable digit of the chela (Figs 3B,C and 26B). These are possibly equivalent to oncofyses (see Hammen, 1967). The antiaxial shelf seems to work against a notch in the rutellum (Figs 26B, 40C) and may aid in breaking food. Their structure is particularly well shown in Figs 3C, 26B. The antiaxial shelf is smaller in *Pheroliodes* but otherwise the significance of these structures as specific or generic characters is not established.

**Epimeral region.** All species in the group have a constant epimeral formula of 3:1:3:3 (setae illustrated though not labelled in Fig. 1B). The three setae of epimeron IV are arranged in a V so that one seta lies lateral to the genital aperture. This seta should not be confused with the aggenital seta which is in a more posterior position. The precise placement of epimeral setae is not considered a useful character in this group and is not described. In several species, particularly some from Western Australia (which also have a caudal notch), the epimeral region (involving epimera III and IV) is markedly convex, anterior to the genital valves, and tends to overhang them (Fig. 38A). This results in a more posterad position of genital seta  $g1$  (Fig. 38F).

**Ventral plate. Genital setae.** There are six to seven pairs of genital setae,  $g1$  being the most anterior (Fig. 1B), usually arranged either in an approximately straight file near the inner margin of each genital valve (Fig. 38F), or in an arc (Fig. 40E). Paschoal (1987b) regarded these

as diagnostic character states respectively for *Hexachaetoniella* and *Pedrocortesella*, although both states are now known for species with five notogastral setae. Additional useful specific characters are the proximity of setae to the inner anterior and posterior corners of the genital valve, and if particular genital setae occur in a marginal notch. *Pedrocortesella temperata* has a seta offset laterad from the others (Fig. 1B).

**Aggenital setae (ag).** There is one pair of aggenital setae, each of which is set lateral to the genital valve, near its posterior corner (Fig. 1B). In *Hexachaetoniella*, they are set posterior to the genital valves (Hunt, 1996b).

**Anal and adanal setae.** There are two pairs of anal setae. These are set in a groove inside the lip of each anal valve (Fig. 1B), a condition which seems common in Plateremaeoidea and Liodoidea. An exception occurs in *P. enigma* which has three pairs of anal setae.

There are usually three adanal setae,  $ad1$  being most posterior and usually occurring posterior to the anal valve (Fig. 1B). Seta  $ad3$  is usually the most laterad and its relative position is a useful specific character. *Pedrocortesella leei* n.sp. and *P. nortoni* have only two pairs of adanal setae, arranged near the posterior end of each valve suggesting  $ad3$  may have been lost.

**Separation of anal and genital vestibules.** The anal and genital vestibules are the cavities in the ventral plate which bear the anal and genital valves. The area between is bridged by integument: the mesal area of integument not affected by transverse grooves is termed the "isthmus". The separation of the vestibules in *Pedrocortesella* has three character states: (i) relatively broad with little or no interruption of ventral plate microsculpture between the vestibules (Fig. 19A); (ii) narrower with interruption to ventral plate microsculpture but with a transversely wide mesal isthmus not affected by strong transverse grooves between the vestibules (Fig. 40A); (iii) very narrow separation with deep transverse grooves and a transversely narrow isthmus (Fig. 38A).

**Legs.** Tarsus I has been surveyed for all species. The pattern of the integument and degree of cerotegumental coating of setae are specific characters (cf. Figs 10A and 19D). The spatial relationships in the tarsal cluster, e.g., whether seta  $ft''$  and the solenidia are contained within the same or separate rims, are of specific importance. A distal recess, which apparently receives the retracted claw complex, is present in some species, and the length of the stalk supporting the claw complex also varies. A condition, which may be termed "terminal compression", occurs in many species—the terminal part of the tarsus between seta  $ft''$  and the claw complex is shortened so that in the extreme case, for example *P. leei* (Fig. 33C), the solenidia  $\omega$ , setae  $(tc)$ ,  $(it)$  and  $(u)$  come to lie almost vertically beneath one another. The cavity containing the undeveloped famulus (seta  $\epsilon$ ) is visible under the scanning electron microscope in only a few species, unlike the situation in *Pheroliodes* where a conspicuous sclerotised ring surrounds the opening of the cavity. As in Australian *Pheroliodes*, *Pedrocortesella* species lack iter setae on the tarsus of leg IV.

*Pedrocortesella* Hammer, 1961

*Pedrocortesella* Hammer, 1961: 38.—P. Balogh, 1985: 49.—Luxton, 1985: 37.—Paschoal, 1987b: 386; 1989: 198.—Balogh & Balogh, 1988: 92; 1992: 48.—Fernandez, 1990: 84.—Eguaras *et al.*, 1990: 276.—Hunt & Lee, 1995: 245. *Acupedicellus* Hunt & Lee, 1995: 232, **new synonym**. (Type species: *A. cornutus* Hunt & Lee, 1995 by original designation.)

**Type species.** *Pedrocortesella pulchra* Hammer, 1961, by monotypy.

**Diagnosis.** Prodorsum with deep transverse furrow, enantiophyses lacking, bothridium abutting notogaster, sensillus nearly always a petiolate blade, rarely a petiolate club; seta *ex* absent; notogaster flattish in lateral aspect, usually concave inside the margin; integument alveolate-reticulate, foveate-reticulate or punctate; 5–6 pairs of notogastral setae, 2–3 of which are anterior to fissura *ip*, setae *p2<sub>x</sub>* never lateral or posterior to *ip*; setae *p2<sub>x</sub>* and *p3<sub>x</sub>* at same level as *h1*, not on posterior flank at same level as *p1*; *lm* if present not mesad of fissura *im* but well posterior to it; seta *ag* anterior to posterior margin of genital valves; 2 (rarely 3) pairs of anal setae, 2–3 pairs adanal; tarsal cluster orientated dorsad or distodorsad, solenidion *omega 1* usually shorter than seta *ft*"; integument of legs usually reticulate or in wavy crests; iter setae absent on tarsus of leg IV.

**Description**

Plateremaeoid mites of medium size (400–750 µm); body covered with layer of cerotegument, reticulation pattern and other high points usually with stellate cushion-like mounds of cerotegument which often coalesce into crests; notogaster of adults ovate, adult carrying exuvial scalps or scalps may be absent or missing; prodorsum with deep transverse furrow but no enantiophyses; seta *le* lateral or dorsolateral, *ro* ventrolateral; seta *ex* absent; seta *in* small, spinous and arising from apophysis; bothridium with posterolateral carina; bothridium abutting notogaster, its posterior wall sometimes incomplete; distal part of sensillus usually a flattened, tuberculate blade; notogaster flattish in lateral aspect, concave

intramarginally, concave area often U-shaped or obovate; integument alveolate-reticulate, foveate-reticulate, or punctate; 5–6 pairs of marginal setae in posterior part of notogaster, setae *h1*, *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* situated dorsally, latter two always anterior to fissura *ip*; *p1* situated on posterior flank ventral to *h1*, *lm* usually absent, if present situated well posterior to fissura *im*; pedipalp tarsus seta *l*" usually with barbs, apophysis supporting eupathidial seta *acm* short; ventral antiaxial and paraxial processes on chelicera well developed; anal and genital plates close; genitoanal chaetotaxy 6–7:1:2 (rarely 3):3 (rarely 2); genital setae either forming straight line near inner margin of plate, or forming an arc; seta *ag* anterior to posterior margin of genital valves; setae *ad1* usually posterior to anal plates, setae *ad3* usually most laterad; cerotegument on legs reticulate, often forming strong wavy crests; leg tarsi heterotridactylous, laterals weaker than central prong; stalk usually short and stout, tarsus sometimes with distal recess to receive retracted ungual complex; tarsal cluster of leg I with seta *ft*" and solenidia *omega 1* and 2 usually surrounded by collar, though former may be partitioned from solenidia; entrance to cavity containing undeveloped famulus (seta *epsilon*) not usually visible under SEM; *omega 1* and 2 usually shorter than *ft*"; iter setae absent on tarsus of leg IV.

**Comments.** The belief by Aoki (1974, 1984) and Ryabini (1986) that *Pedrocortesella* is a junior synonym of *Pedrocortesia* is not accepted in this work. *Pedrocortesia* is now regarded by most authors as a junior synonym of *Pheroliodes*, whereas *Pedrocortesella* is regarded as a separate taxon (Hunt & Lee, 1995).

Hunt & Lee (1995) erected the monotypic genus *Acupedicellus* for *A. cornutus*. Increased knowledge of the Australian fauna and re-examination of the type species of *Pedrocortesella* suggest that the variation in leg I structure on which the genus was based does not warrant separate generic status. The dorsal apophysis on the femur of leg I and the tapering tarsus are best regarded as autapomorphies for the species. The species becomes *Pedrocortesella cornuta*, n.comb.

The nominal species *P. dispersa* and *P. queenslandica* each represent radiations which warrant separate generic status and are redescribed elsewhere (Hunt, 1996b; 1996c).

**Key to adults of Australian species of *Pedrocortesella***

(For identification under transmitted light the animal should be cleared. Scalps, if present, should be noted and removed to assist identification).

- 1 Terminal part of sensillus a flattened blade (Figs 39D and 39A show different aspects), curved and not truncate distally ..... 2
- Terminal part of sensillus either with a rounded club-like head (Fig. 34E) or truncate distally (Fig. 46B) ..... 21
- 2 Notogaster with large seta placed mesad of most anterior marginal seta (Fig. 1A) ..... *P. augusta* n.sp.
- Notogaster without a seta placed mesad of most anterior marginal seta (Fig. 41E) ..... 3
- 3 Notogaster with conspicuous caudal concavity or notch (when body is horizontal and viewed from above) (Fig. 22A) ..... 4

- Notogaster without conspicuous caudal concavity or notch  
(when body is horizontal and viewed from above) (Fig. 39A)..... 10
- 4 Notogaster pitted by punctations or small foveae (Fig. 41E)..... 6
- Notogaster not pitted by punctations or small foveae ..... 5
- 5 Notogaster centrodorsally with an irregular pattern of ridges  
(Fig. 25A) ..... *P. hangayi* n.sp.
- Notogaster centrodorsally reticulate, anteriorly with prominent  
mesal carina (Fig. 22A)..... *P. gunjina* n.sp.
- 6 Femur of leg I with very strong dorsal process; or tarsus of  
leg I gradually tapering to the stalk supporting claw complex  
(see fig. 6D in Hunt & Lee, 1995) ..... *P. cornuta* (Hunt & Lee) n.comb.
- Femur of leg I without a strong dorsal process; tarsus of leg  
I with abrupt transition to the stalk supporting the claw  
complex..... 7
- 7 Notogastral setae including cerotegument leaf-shaped (Fig.  
41F); northern Australia..... *P. subula* n.sp.
- Notogastral setae including cerotegument not leaf shaped (Fig.  
14B,D); northern or southern Australia ..... 8
- 8 Notogastral integument with reticulate pattern of high relief,  
particularly around margins (Fig. 16A); north-west Australia ..... *P. calmorum* n.sp.
- Notogastral integument without reticulate pattern of high relief  
(Fig. 5D), most conspicuous elements of notogastral integument  
are foveae or punctations; southern Australia..... 9
- 9 Lateral notogastral setae arising from pits no larger than  
punctations or foveae (Fig. 37E); epimera III-IV form a  
prominent V-shaped fold over the genital valves (Fig. 38A)..... *P. obesa* n.sp.
- Lateral notogastral setae arising from pits much larger than  
punctations or small foveae (Fig. 14B); epimera III-IV form  
a weak V-shaped fold over the genital valves (Fig. 15A)..... *P. callitarsus* n.sp.
- 10 Notogaster punctate (Fig. 14B); or, if foveate, at least some  
foveae perforated by pores (Fig. 39B); or pores may lie in  
small foveae between irregular transverse ridges (Fig. 2A,D)..... 11
- Notogaster not punctate and without visible pores in foveae;  
notogaster with foveae or alveoli..... 13
- 11 Notogaster with conspicuous broad foveae, or pores in small  
foveae (which may appear as punctations) lying between  
irregular transverse ridges (Fig. 2A,D)..... 12
- Notogaster without broad foveae or transverse ridges, covered  
with numerous punctations ..... *P. callitarsus* n.sp.
- 12 Notogaster without transverse ridges (Fig. 39A,B); insertion  
of seta *ad3* level with anterior 30% of anal valve (Fig. 40G) ..... *P. propinqua* P. Balogh
- Notogaster with irregular transverse ridges (Fig. 2A,D);  
insertion of seta *ad3* level with posterior 66% of anal valve ..... *P. anica* n.sp.
- 13 Notogaster with rounded foveae, (Fig. 31A); or only 2 adanal  
setae on each side ..... *P. leeii* n.sp.

- Notogaster reticulate with angular (Fig. 8A) or irregular (Fig. 25A) depressions; or 3 adanal setae on each side ..... 14
- 14 Each genital valve with 6 setae close to the inner lip and with another seta offset laterad (Fig. 1B)..... *P. temperata* P. Balogh
- Each genital valve without an offset seta, all 6–7 setae arranged in straight or arcuate file..... 15
- 15 Six setae on each genital valve ..... 16
- Seven setae on each genital valve ..... 18
- 16 Notogaster with fairly uniform reticulate pattern (Figs 20F, 18A); notogaster with 6 pairs of setae ..... 17
- Notogaster with irregular pattern of reticulations and ridges (fig. 1A in Hunt & Lee, 1995); notogaster with 5 pairs of setae ..... *P. semireticulata* Hunt & Lee
- 17 3 pairs of notogastral setae inserted anterior to fissura *ip* ..... *P. kanangra* n.sp.
- Less than 3 pairs of notogastral setae inserted anterior to fissura *ip* ..... *P. conundrum* n.sp.
- 18 Reticulate pattern across entire notogaster bold and regular (Fig. 11A) ..... 20
- Reticulate pattern on central part of notogaster very subdued (fig. 3G,I in Hunt & Lee, 1995); or bold but not of regular form across entire notogaster (Fig. 27A)..... 19
- 19 Reticulate pattern on notogaster very subdued (Fig. 3G&I in Hunt & Lee, 1995); scalps firmly held on notogaster... *P. cryptoreticulata* Hunt & Lee
- Reticulate pattern on notogaster bold but irregular (Fig. 27A); lateral notogastral setae arise from small apophyses (Fig. 27F); scalps if present loosely attached ..... *P. impedita* n.sp.
- 20 Notogastral setae long, coated with thick cerotegument (Fig. 8G); Western Australia..... *P. bannisteri* n.sp.
- Notogastral setae short, not coated with thick cerotegument (Fig. 11G); eastern Australia..... *P. bithongabela* n.sp.
- 21 Sensillus with a rounded club-like head (Fig. 34E); Tasmania..... 22
- Sensillus truncate (Fig. 46B,C); 2 pairs of anal setae; eastern mainland Australia ..... *P. truncata* n.sp.
- 22 Two pairs of anal setae and 2 pairs of adanal setae ..... *P. nortoni* n.sp.
- Three pairs of anal setae and 3 pairs of adanal setae ..... *P. enigma* n.sp.

#### Descriptions of *Pedrocortesella* species

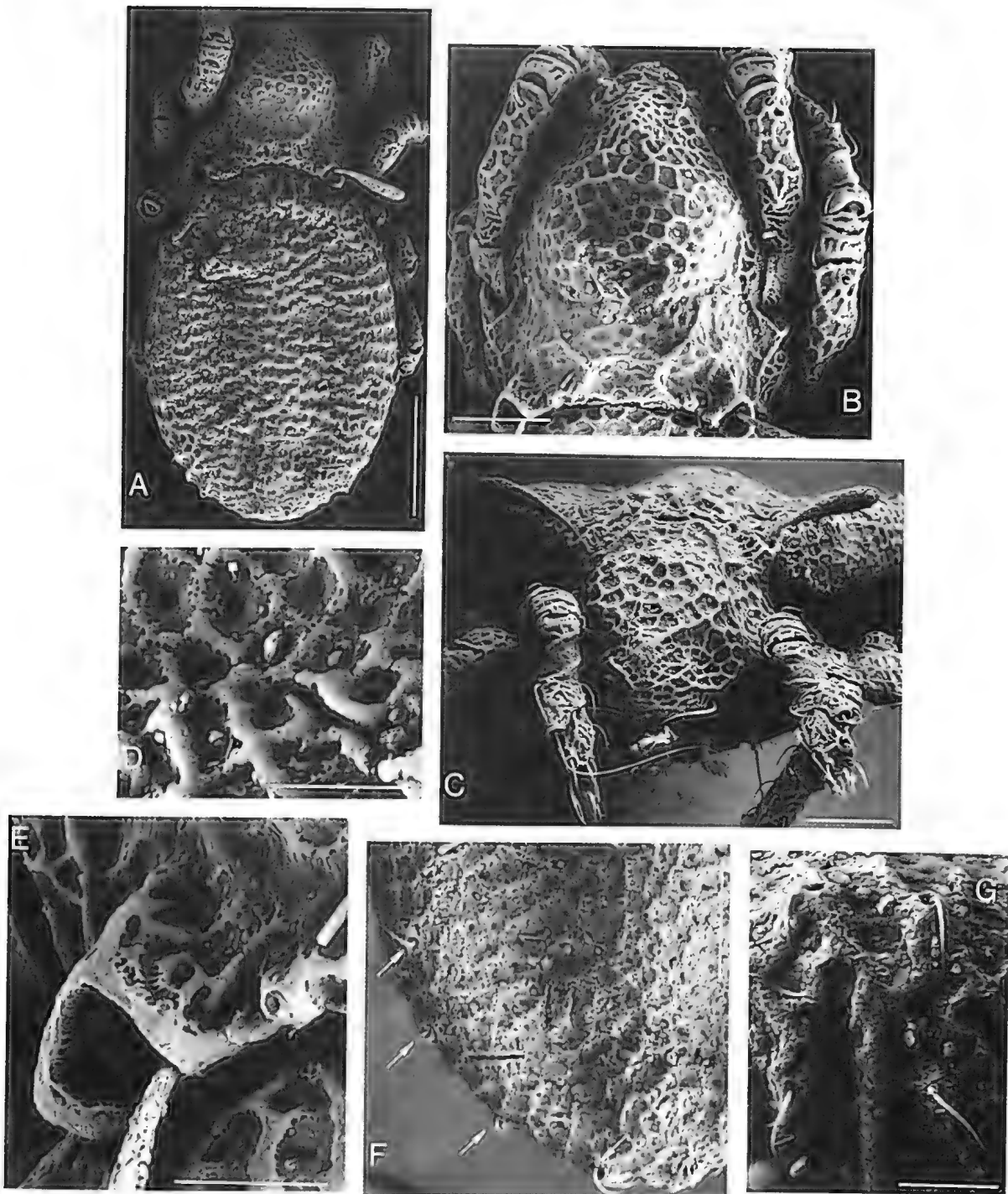
##### *Pedrocortesella anica* n.sp.

Figs 2, 3, 4A–C

**Type material.** Australian Capital Territory: HOLOTYPE adult. ANIC, Black Mountain, Canberra, 35°16'S 149°06'E, open forest, extraction leaf litter, ANIC berlesate 1067, T. Weir, 20 October 1986. PARATYPE adults. ANIC, same data as

holotype, 6 adults; AM KS46544, SEM stub no. S/256 (ill.), same data 5 adults; AM KS43682, same data, 2 adults; FMNH, same data, 2 adults; CNC, same data, 2 adults; AM KS46546, SEM stub no. S/170 (ill.), beside Federal Highway, just N. of Canberra on NSW/ACT border, 35°23'S 149°23'E, open forest beneath *E. viminalis*, berlese extraction of leaf litter, G.S. Hunt, 10 May 1992, 3 adults; AM KS43683, same data, 13 adults; AM KS46557, SEM stub no. S/122 (ill.), 1 km





**Fig. 2.** *Pedrocortesella anica* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, prodorsum, frontal; D, notogastral integument and fissura *im*; E, bothridium and seta *in*, dorsal; F, part of posterior of notogaster, dorsal, arrows right to left label setae *h1*, *lp*, *p2*, *p3*; G, notogastral setae *h1* and *p1*, posterior view. Scale bars: A = 100 µm; B,C,F = 50 µm; D,G,E = 20 µm. A,C,F,G = Canberra; B,D,E = Mount Gingera.

N. of Mount Gingera, 35°33'S 148°47'E, berlese extraction moss, ANIC berlesate 699, A. Calder, 18 February 1981, 3 adults.

**Other material examined.** New South Wales: AM KS46558, SEM stub no. S/243, Kanangra-Boyd National Park, 34°03'S 150°05'E, closed forest, berlese extraction, litter and moss, ANIC berlesate 828, L. Hill, 20 March 1992, 2 adults; AM KS46559, SEM stub no. S/119, 4.8 km E.N.E. of Moruya, 35°55'S 150°06'E, ANIC berlesate 267, tea tree, N.J. Mitchell 30 March 1970, 2 adults; AM KS43684, Adaminaby, 36°00'S 148°47'E, ex soil in paddock, 18 June 1984, 4 adults.

**Diagnosis.** Body medium, length about 450–550 µm; scalps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster reticulate-

foveate, each small fovea perforated by pore, integument with transverse ridges between lines of foveae; 5 pairs of notogastral setae, each arising from pit; genitoanal chaetotaxy 7:1:2:3, genital setae in essentially straight file, insertion of seta *ad3* adjacent to posterior half of anal valve; claw stalk very short.

### Description

**ADULT:** *Body:* brown; length (µm) 450, 460, 520, 530. *Cerotegument:* body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster and rim of bothridium highlighted with crests of cerotegument (Fig. 2D,E). Setae *ro* and *le* and notogastral

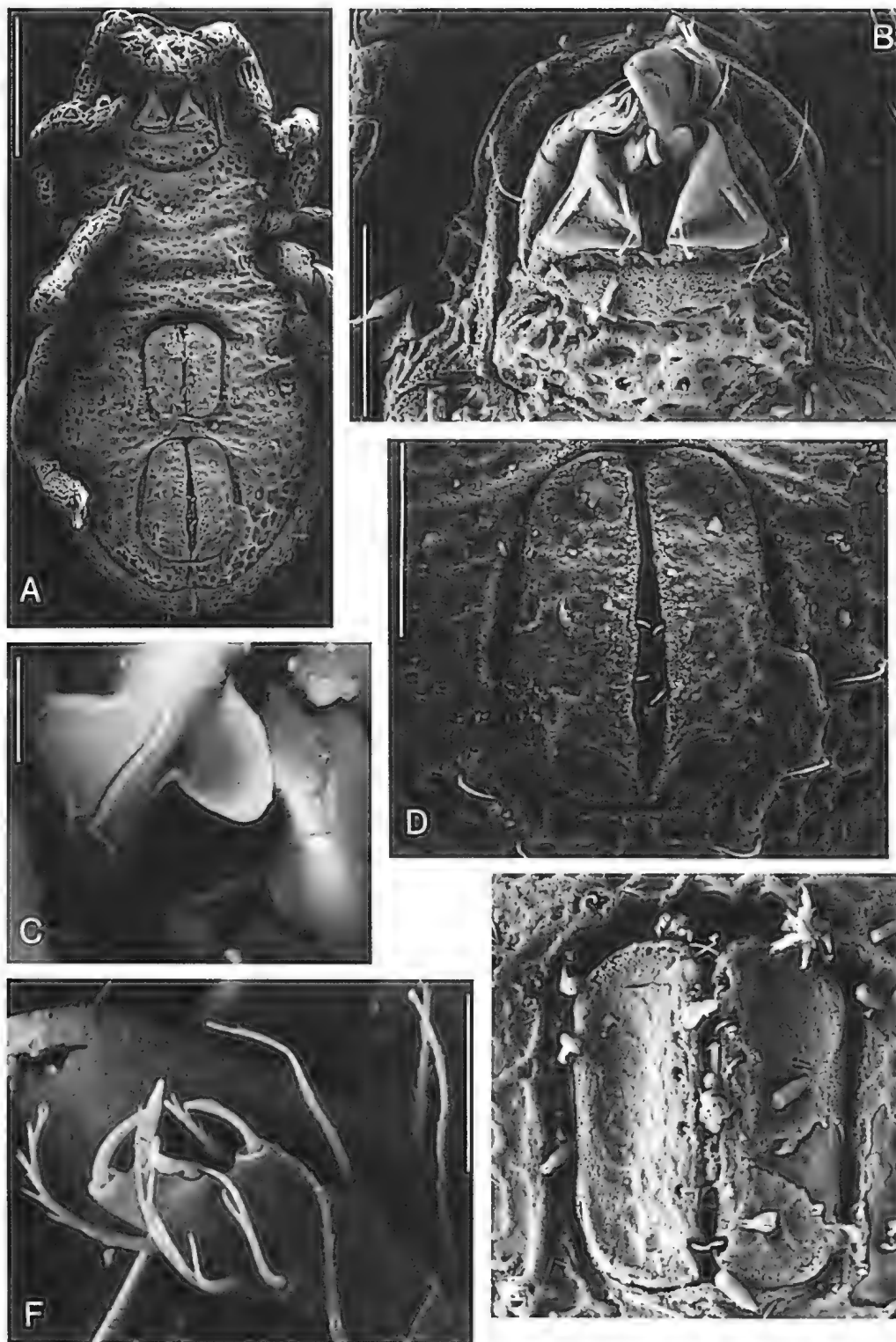


Fig. 3. *Pedrocortesella anica* n.sp. A, body, ventral; B, subcapitulum; C, chelicera: ventral paraxial and anti-axial processes; D, anal valves; E, genital valves; F, pedipalp. Scale bars: A = 100  $\mu$ m; B,D,E = 50  $\mu$ m; F = 10  $\mu$ m; C = 5  $\mu$ m. A,C,D,F = Canberra; B,E = Mount Gingera.

setae without obvious cerotegument. *Prodorsum*: integument reticulate-alveolate particularly anterior to median transverse groove, some alveoli with pores; carina between *le* and *ro* present or absent; *le* dorsolateral, distance between them about 0.60 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal tooth tapering to more delicate point than *P. propinqua*. Bothridium closely adpressed to notogaster (Fig. 2E),

wall subtriangular and depressed posteriorly and anterolaterally, posterolateral carina moderately strong, situated close to notogaster; sensillus length about 0.9 interbothridial distance, with long flattened tuberculate blade (Fig. 2C), posterior margin of prodorsum forming a somewhat irregular arc between bothridia. *in* small, set  $>0.5 < 1.0$  bothridial diameter from bothridial wall, at edge of dorsosejugal furrow, spiniform, largely



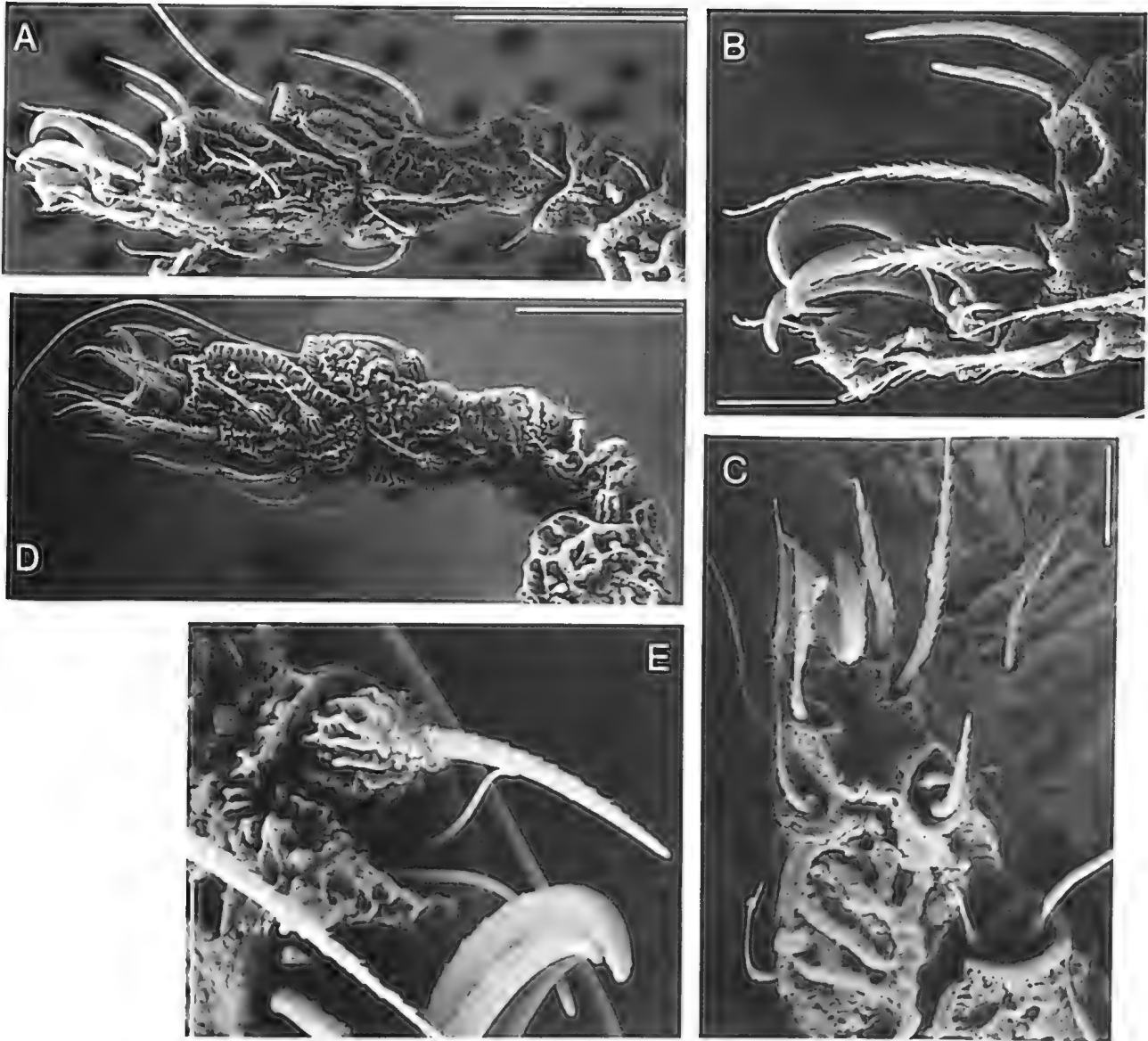


Fig. 4. *Pedrocortesella* spp. Leg I structures. A–C: *Pedrocortesella anica* n.sp. A, genu, tibia and tarsus, antiaxial; B, detail tarsus, distal; C, tibia (distal) and tarsus, dorsal. D,E: *Pedrocortesella callitarsus* n.sp. D, genu, tibia and tarsus, antiaxial; E, tarsal cluster, detail. Scale bars: A,D = 50  $\mu$ m; B,C,E = 10  $\mu$ m. A–C = Canberra; D,E = Mount Gingera.

encased in cerotegument (Fig. 2E). *Exuvial scalps*: none seen. *Notogaster*: oval, length:width 320:250, 350:270. Intramarginal depression oval. Notogaster foveate-reticulate and perforated by pores, patterning of integument tending to form subtransverse wavy ridges, more pronounced laterally, connecting ridges weaker (Fig. 2A,D,F); posterior margin barely invaginate when viewed from above, with a strong carina between setae *p1* when viewed posteriorly (Fig. 2G). Fissura *ia* subparallel-oblique, *im* oblique and *ip* oblique-perpendicular to sagittal plane; 5 pairs of short notogastral setae arising from pits larger than adjacent punctations; *h1* moderately separated, each located just inside posterior margin; *p1* inserted lower than midheight on posterior flank, similarly spaced or slightly further apart than *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise just inside posterolateral flank, their insertions easily visible from above, *lp<sub>x</sub>* and *p2<sub>x</sub>* subequidistant from fissura *ip*, *lp<sub>x</sub>* inserted posterior to it (Fig. 2F). *Gnathosoma*: cheliceral movable finger ventrolaterally with prominent shelf on antiaxial surface

and larger but more flexible flap on paraxial surface. Rutella basally with moderate concave flexure and strong pair of lateral buttress, small pointed mesad processes present, transverse striations absent (Fig. 3B). Pedipalp tarsus with setae (*vt*) and *l''* with long barbs, *cm* with short barbs, apophysis supporting seta *acm* short; solenidion *omega* almost reaching to base of *acm*. *Epimeral region*: strongly convex anterior to genital valves, though not tending to overhang them. *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 3A). Ventral plate reticulate-alveolate. Genitoanal chaetotaxy 7:1:2:3; genital setae essentially in straight file (Fig. 3E), *g1* subequal to other setae, at anterior corner in marginal notch; *g5* situated at about 0.5 valve length, *g7* inserted well anterior to inner posterior corner in marginal notch; setae *ag* inserted at level of *g7*; setae *ad1* distinctly postanal, *ad3* level with posterior half of anal valve; *ad1*–3 inserted

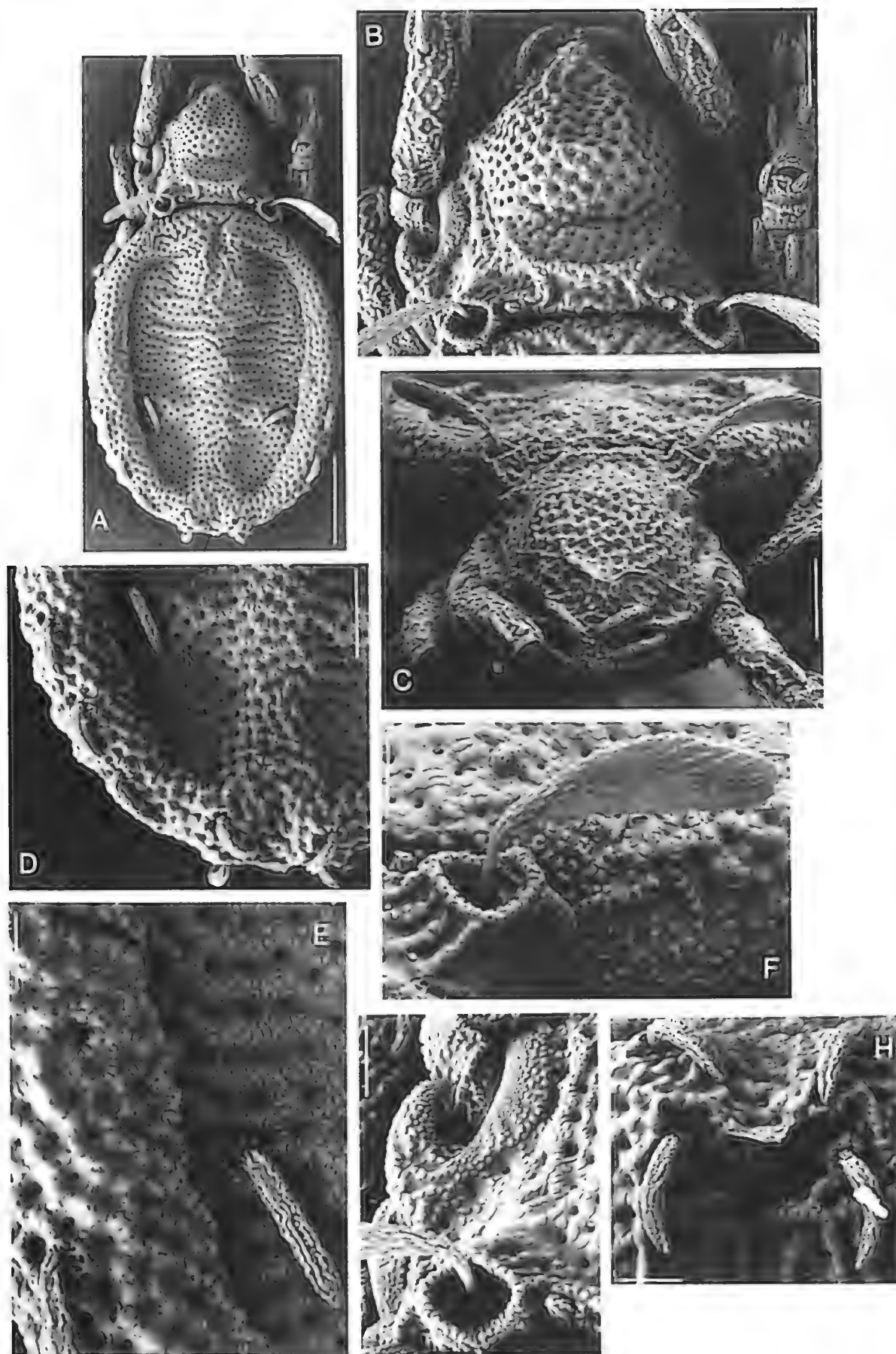


Fig. 5. *Pedrocortesella augusta* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, prodorsum, frontal; D, posterior part of notogaster, dorsal; E, notogastral integument, fissura *im* and notogastral setae *lm* and *p3*; F, bothridium, sensillus and seta *in*, lateral; G, bothridium, seta *in* and pedotectal tooth *p*, dorsal; H, notogastral setae *hl* and *p1*, posterior view. Scale bars: A = 100 µm; B-D = 50 µm; E-H = 20 µm.

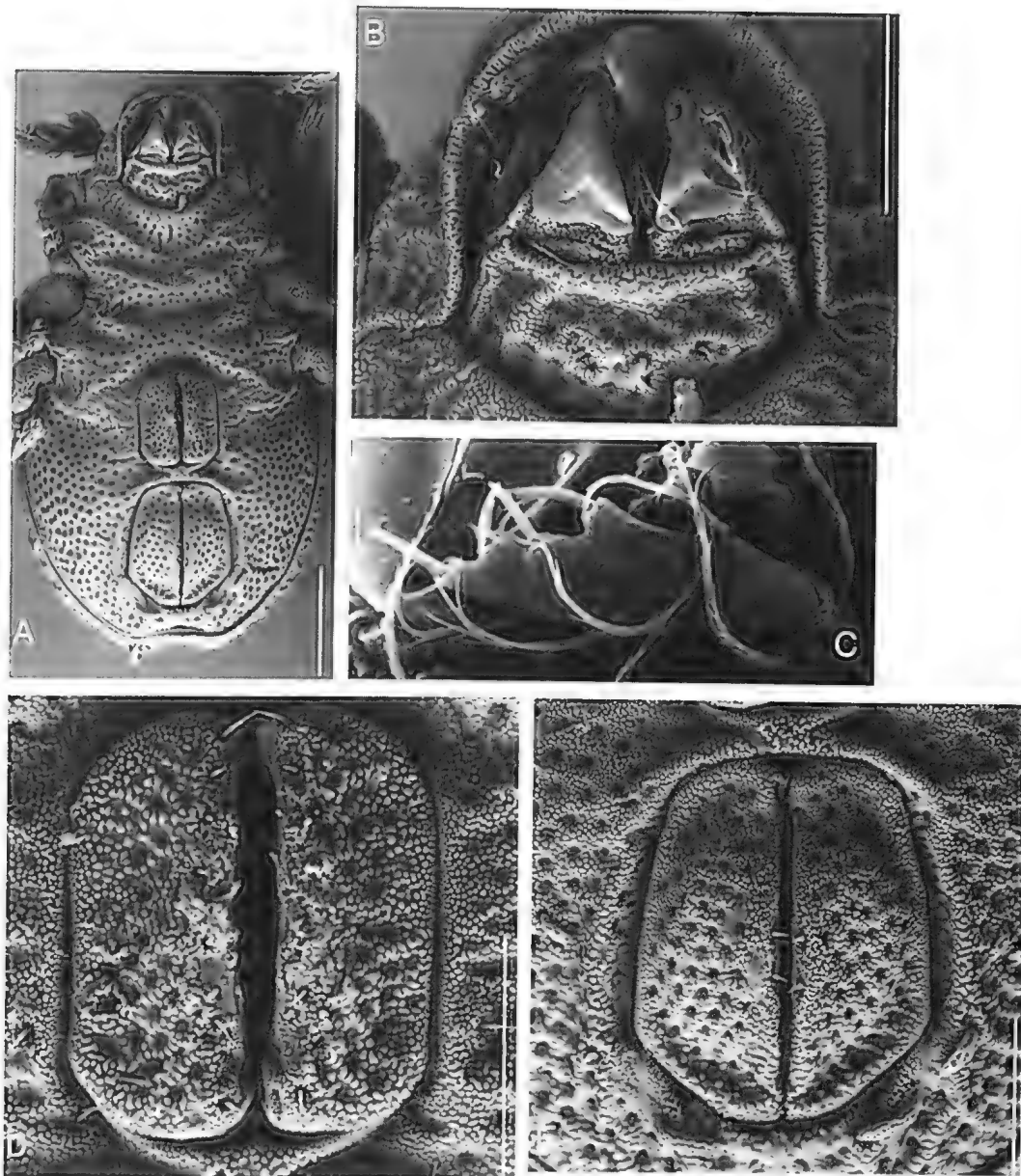


Fig. 6. *Pedrocortesella augusta* n.sp. A, body, ventral; B, subcapitulum; C, pedipalp tarsus, antiaxial; D, genital valves; E, anal valves. Scale bars: A = 100 µm; B,D,E = 50 µm; C = 10 µm.

in small pits (Fig. 3D). *Legs*. Distal apophysis of tibia overlaps about 40% of tarsus (Fig. 4A). Tarsal cluster of leg I placed distodorsally on apophysis, slightly proximodorsal to setae *tc*; *ft*", *omega* 1 and 2 enclosed in well-developed almost circular common rim, no partition separating *ft*" from *omega* 1 and 2; *ft*" longer than solenidia; tarsus with distal recess for receiving retracted unguital complex (Fig. 4C), stalk very short (Fig. 4B).

**Variation.** The Kanangra-Boyd National Park specimen has a single buttress on the rutellum. The Moruya specimen, which has seta *in* very close to the bothridium, six pairs of genital setae, and a slightly different patterning of the notogaster, may belong to a different species.

**Etymology.** The specific epithet is the Latinised acronym of Australian National Insect Collection (ANIC) whose staff collected much of the material.

**Distribution.** SE New South Wales, and Australian Capital Territory.

### *Pedrocortesella augusta* n.sp.

Figs 1A, 5–7

**Type material.** Western Australia: HOLOTYPE adult, WAM, Augustus Island, CALM Site 26/1, 15°25'S 124°38'E, closed forest litter, ANIC berlesate 1082A, I.D. Naumann, 11–16 June 1988. PARATYPE adults. AM KS46535, SEM stub no. S/355 (ill.), same data as holotype, 1 adult; WAM, SEM stub no. S/149 (ill.), same data, 3 adults; AM KS43677, same data, 1 adult; CNC, same data, 1 adult; ANIC same data, 4 adults.

**Diagnosis.** Body medium, length about 500–600 µm; scaps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster reticulate-foveate, each fovea with pore, notogaster with slight caudal notch when viewed from above, anteriorly with a mesal groove, 6 pairs of long notogastral setae, seta *lm* lying well inside lateral margin mesad to most anterior marginal seta; genitoanal chaetotaxy 7:1:2:3, genital setae in slightly arcuate file, level of insertion of seta *ad*3 at about 0.5 anal valve length; claw stalk short.

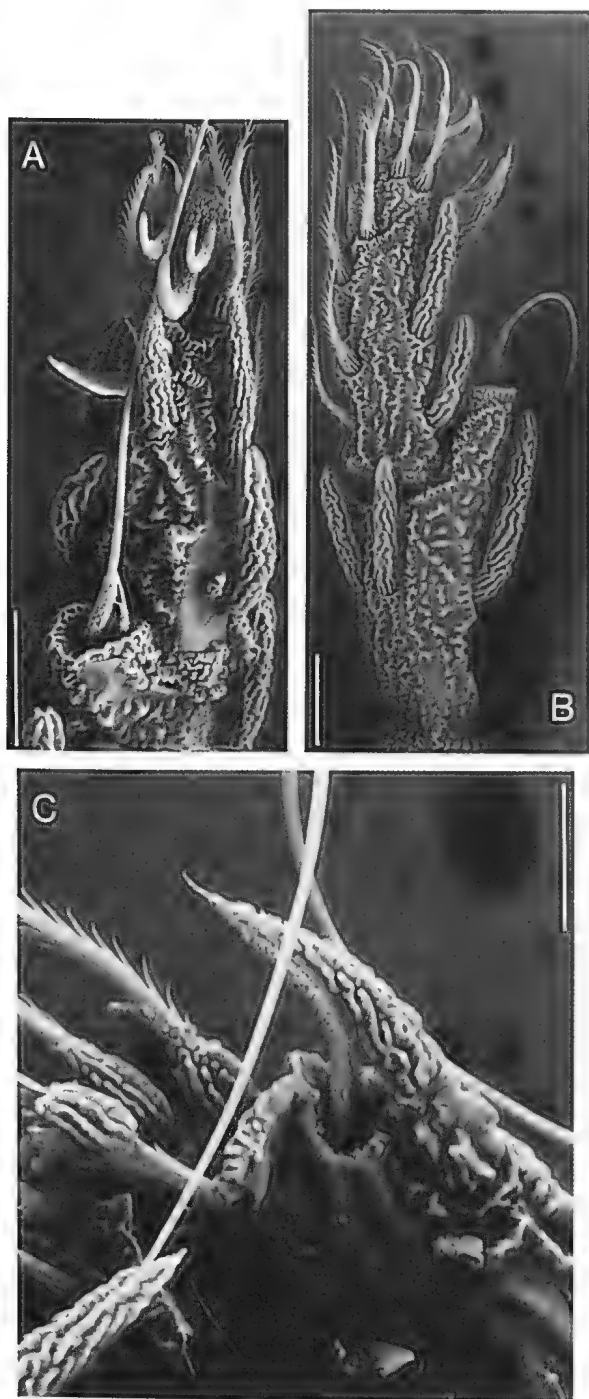


Fig. 7. *Pedrocortesella augusta* n.sp. Leg I structures. A, tibia (distal) and tarsus (dorsal); B, tibia and tarsus, paraxial; C, tarsal cluster, dorso-antiaxial. Scale bars: A,B = 20  $\mu$ m; C = 10  $\mu$ m.

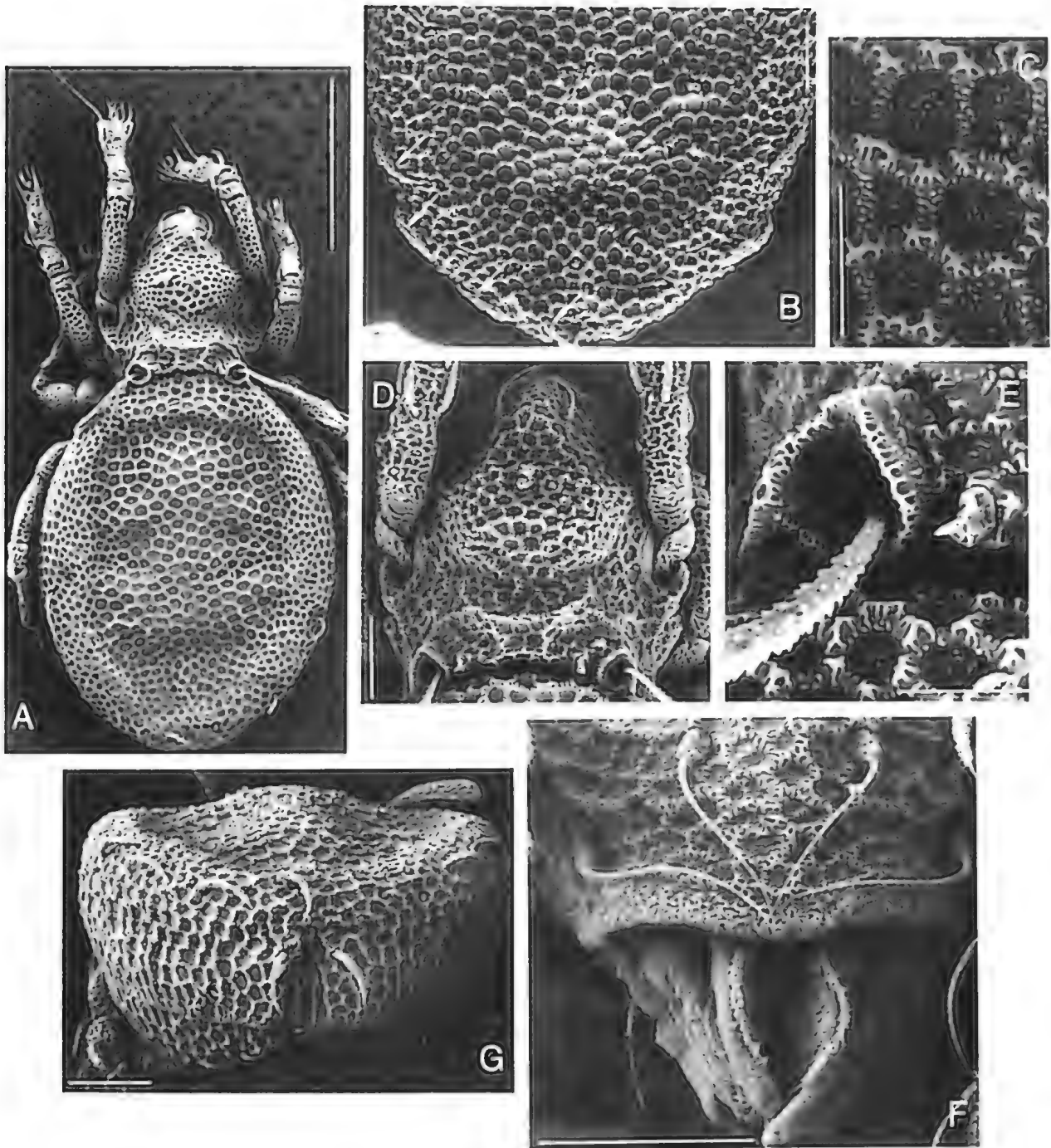
### Description

**ADULT:** *Body:* brown; length ( $\mu$ m) 520, 540, 550, 560. *Cerotegument:* body generally with thin veneer of cerotegument with irregular raised patches on walls surrounding punctations on notogaster (Fig. 5E) and granules on venter (Fig. 6D,E). Setae *ro* and *le*, notogastral and leg setae with longitudinal wavy ribs of cerotegument. *Prodorsum:* integument punctate (Fig. 5B). *le* dorsolateral, distance between them about 0.7 distance between *ro*, not arising from large pit, *ro* ventrolateral; weak carina between *le* and *ro*. Pedotectal tooth stouter than in *P. propinqua*, prodorsum with

prominent condyle-like surface dorsal to trochanter I. Bothridium abutting but not closely adpressed to notogaster (Fig. 5B), wall somewhat oval shaped, posterior wall not deeply excavated, posterolateral carina moderately strong, arising away from notogaster; sensillus length subequal to interbothridial distance, with long flattened tuberculate blade (Fig. 5C). *in* small, set close bothridium and at edge of dorsosejugal furrow, encased in cerotegument (Fig. 5C,F). *Exuvial scalps:* none seen. *Notogaster:* oval, length:width 370:290. Raised lateral margins very sharply delineated from intramarginal depression by distinct line; depression divided into two by mesal saddle; anterior margin with longitudinal mesal groove (Fig. 5A,C). Notogaster punctate or foveate-reticulate, each small fovea perforated by a large pore (Fig. 5E); posterior margin slightly invaginate when viewed from above, without a mesal carina when viewed posteriorly (Fig. 5H). Fissura *ia* subparallel and *im* and *ip* oblique to sagittal plane; *gla* conspicuous and close to *im*. 6 pairs of notogastral setae; *hl* widely separated, each located inside posterior margin; *p1* inserted high on posterior flank, similar distance apart to *hl*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise just inside posterolateral flank, their insertions easily visible from above, *lm* arises well inside lateral margin within the intramarginal depression and slightly anterior to *p3* but well posterior to both fissura *im* and *gla*. *lp<sub>x</sub>* closest to fissura *ip*, inserted lateral to it (Fig. 5D), and *lm* closest to fissura *im*. *Gnathosoma:* rutella basally with strong chevron-shaped concave flexure and weak lateral buttressing, pointed mesad processes and transverse striations absent (Fig. 6B). Pedipalp tarsus with setae *l''* and (*vt*) with very long barbs, *cm* branches short; apophysis supporting seta *acm* moderately strong; solenidion *omega* short, not reaching to base of *acm*. *Epimeral region:* epimera IV very strongly convex immediately anterior and lateral to genital valves, though not overhanging them. *Genitoanal region:* separation of anal and genital vestibules relatively narrow with deep transverse grooves and a narrow isthmus between the vestibules (Fig. 6A). Ventral plate punctate. Genitoanal chaetotaxy 7:1:2:3; genital setae essentially in straight file, *g1* inserted just inside inner anterior corner, not in marginal notch; *g5* situated at about 0.5 valve length, *g7* inserted anterior to inner posterior corner, not in marginal notch; setae *ag* inserted at level posterior to *g6*; setae *ad1* distinctly postanal, *ad3* level at about 0.5 length of anal valve. *Legs.* Distal apophysis of tibia overlaps less than 30% of tarsus (Fig. 7B). Tarsal setae (*pl*) and (*ft*) almost entirely enclosed by longitudinal ribs of cerotegument. Tarsal cluster of leg I placed distodorsally on apophysis, above and slightly proximal to setae *tc*; *ft''* enclosed in poorly defined rim; *omega 1* and 2 close together with a separate rim elevated on an apophysis; *ft''* slightly longer than solenidia; tarsus lacking distal recess for receiving retracted unguital complex, stalk short.

**Comments.** The distinct separation of tarsus I seta *ft''* from the solenidia in this species is unusual for Australian *Pedrocortesella*, as is having six pairs of notogastral setae. The placement of the additional seta is very similar to that in *P. japonica* Aoki & Suzuki (subsequently placed in *Hexachaetoniella* by Paschoal (1987b) and labelled as seta *h2* by Aoki & Suzuki (1970, fig. 1). Further investigation may warrant erection of a new genus for these two species.





**Fig. 8.** *Pedrocortesella bannisteri* n.sp. A, body, dorsal; B, notogaster, posterior, dorsal, arrows right to left label setae *hl*, *lp*, *p2*, *p3*. C, notogastral integument; D, prodorsum, dorsal; E, bothridium and seta *in*, dorsal; F, rostrum, frontal; G, notogaster, posterior. Scale bars: A = 200  $\mu$ m; B,D,F,G = 50  $\mu$ m; C,E = 20  $\mu$ m.

**Etymology.** The specific epithet refers to the animal's impressive qualities and alludes to Augustus Island on which the species occurs.

**Distribution.** Augustus Island, Western Australia.

*Pedrocortesella bannisteri* n.sp.

Figs 8, 9, 10D–E

**Type material.** Western Australia: HOLOTYPE adult. WAM, York, 31°53'S 116°46'E, Powder bark/Mallee leaf litter, berlesate, J. Bannister, 2 November 1991. PARATYPE adults. AM KS46524, SEM stub 150 (ill.); same data as holotype, 2 adults; AM KS43671, same data, 1 adult.

**Other material examined.** Western Australia: AM KS46525, SEM stub no. S/147 (ill.), Mount York, 31°53'S 116°48'E, berlesate She-oak litter, J. Bannister, 16 November 1991, 1 adult.

**Diagnosis.** Body medium-large, length about 550–700  $\mu$ m; scalps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster entirely alveolate-reticulate, without pores in alveoli, notogaster without caudal notch when viewed from above; 5 pairs of long notogastral setae; genital and anal vestibules widely separated; genitoanal chaetotaxy 7:1:2:3, genital setae in arcuate file, level of insertion of *ad3* between proximal 30–40% of anal valve; claw stalk medium.

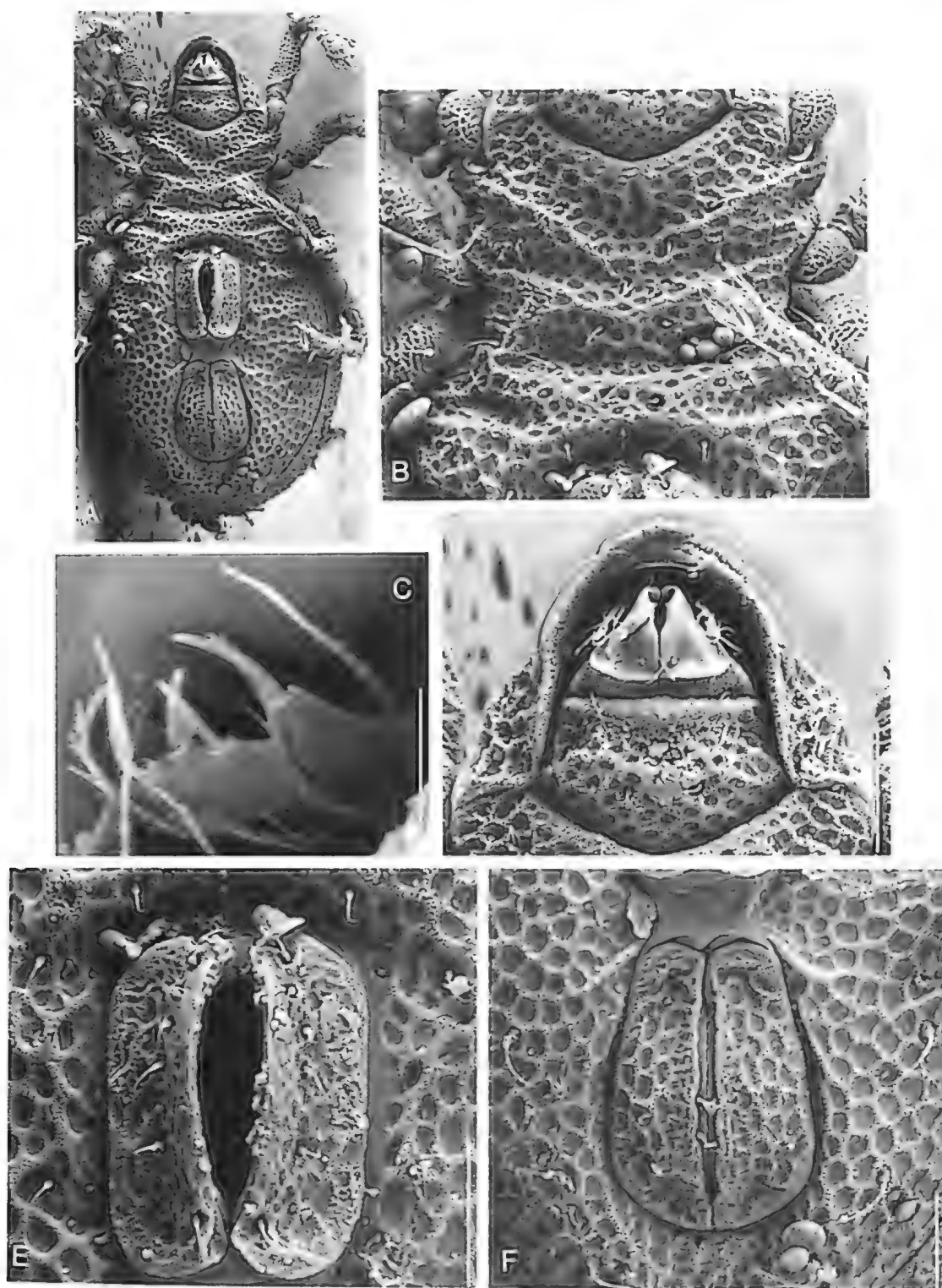
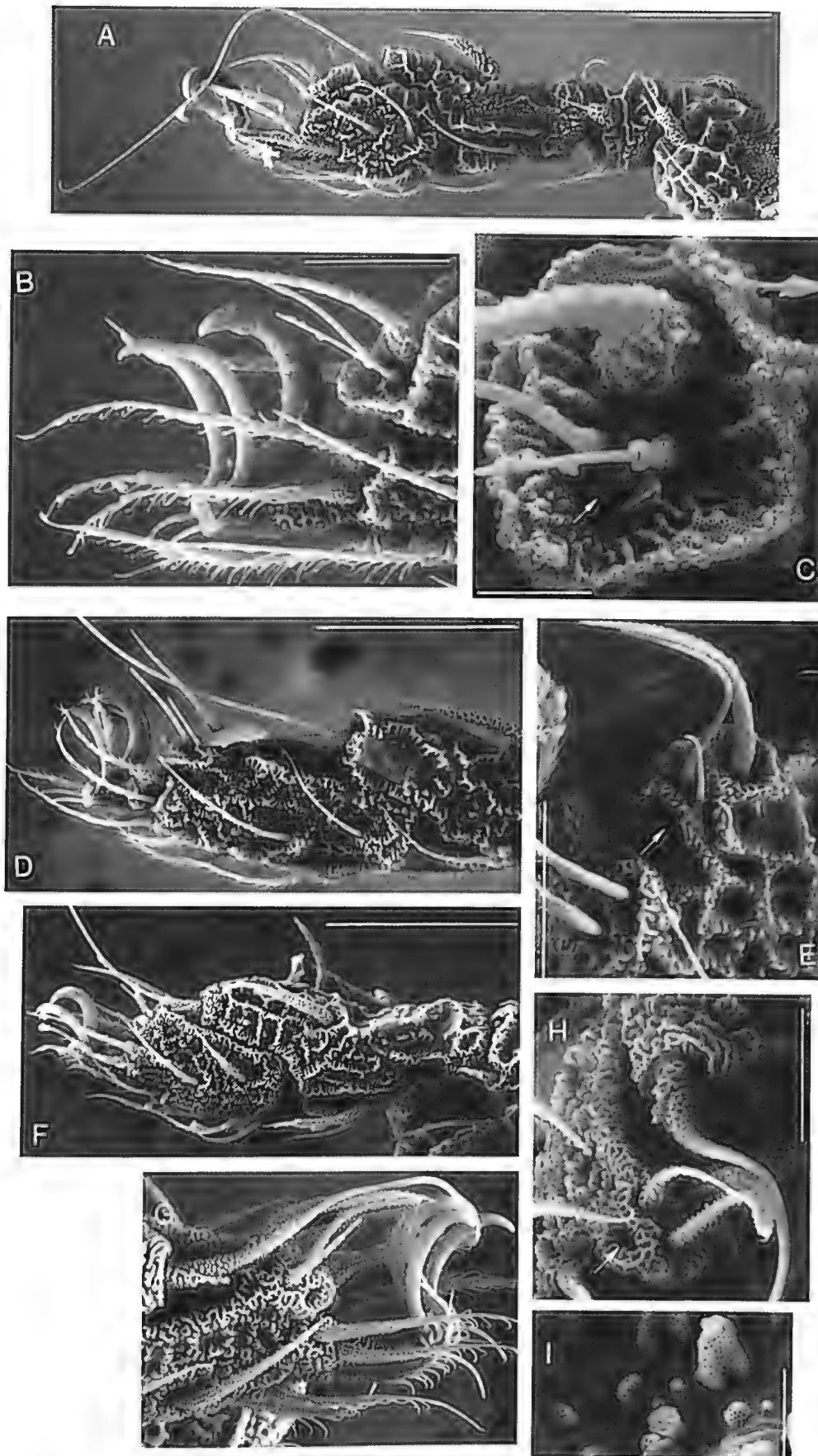


Fig. 9. *Pedrocortesella bannisteri* nsp. A, body, ventral; B, epimeral region; C, pedipalp tarsus; D, subcapitulum; E, genital valves; F, anal valves. Scale bars: A = 200  $\mu\text{m}$ ; B,D-F = 50  $\mu\text{m}$ ; C = 10  $\mu\text{m}$ .

### Description

**ADULT: Body:** brown; length of 4 specimens from the York area are 590, 640, 650 and 670  $\mu\text{m}$ . **Cerotegument:** crests of reticulations on prodorsum and notogaster and rim of bothridium with stellate tubercles of cerotegument which may coalesce giving a "stitched" appearance (Fig. 8C); alveoli with scattered granules of cerotegument (Fig. 8C). Setae *ro* and *le* and notogastral setae with heavy, tapering ribbed encrustation of cerotegument

along most their length (Fig. 8G). Legs with cerotegument capping the reticulate surface ornamentation which is of much lower relief than in *P. propinqua*. **Prodorsum:** integument divided into 2 fields: anterior to median transverse furrow reticulate-foveate, foveae not perforated by pore, reticulations larger towards the rostrum; a bothridial field of more complex topography with reticulations and carinae (Fig. 8D). *le* dorsolateral, distance between them about 0.3–0.5 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal



**Fig. 10.** *Pedrocortesella* spp. A–C,I: *Pedrocortesella propinqua* P. Balogh; A, genu, tibia and tarsus, antiaxial; B, detail of tarsus, distal; C, detail of tarsal cluster; I, alveolus of seta *in* (seta broken) and surrounding cerotegument tubercles. D–E. *Pedrocortesella bannisteri* n.sp.; D, tibia (distal) and tarsus, antiaxial; E, detail of tarsal cluster. F–H: *Pedrocortesella obesa*, n.sp.; F, tibia and tarsus, antiaxial; G, detail of tarsus, distal; H, detail of tarsal cluster. Arrows to presumed opening to cavity containing undeveloped famulus (seta *epsilon*). Scale bars: A,D,F = 50  $\mu$ m, B,E = 20  $\mu$ m; G,H = 10  $\mu$ m; C,I = 5  $\mu$ m. A = Casino; B,C = Mount Allyn; D,E = Mount York; F–H = Margaret River; I = Gulpa Island.



tooth similar to *P. propinqua*. Bothridium closely adpressed to notogaster, wall more deeply excavated posteriorly (Fig. 8E) and more rounded than in *P. propinqua*; posterolateral carina situated close to notogaster; sensillus length subequal to interbothridial distance, with long flattened tuberculate blade, broadest subdistally and rounded at end (Fig. 8G). Setae *in* small, set near bothridium at edge of dorsosejugal furrow, spiniform but basally encased in cerotegument (Fig. 8E). *Exuvial scalps*: none seen. *Notogaster*: oval but wide, length:width 2 specimens 440:360, 440:350. Intramarginal depression obovate, broadest anteriorly, not interrupted posteriorly. Dorsum entirely alveolate-reticulate, without pores in alveoli (Fig. 8C). Posterior margin not invaginate when viewed from above, with slight mesal furrow and no prominent carina (though reticulations may become linear) ventral to setae *p1* when viewed posteriorly (Fig. 8G). Fissura small; *ia* subparallel, *im* oblique and *ip* subperpendicular to sagittal plane. 5 pairs of long notogastral setae; *h1* widely separated but converging at their tips, each located just inside posterior margin; *p1* inserted high on posterior flank, slightly closer together than *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise on posterolateral flank, their insertions just visible from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted posterior to it (Fig. 8B). *Gnathosoma*: pedipalp tarsus with setae (*vt*) and *l''* with very long barbs, *cm* barbs very short; apophysis supporting seta *acm* low; solenidion *omega* reaching to base of *acm*. Rutella basally with moderate concave flexure and buttressing, but without pointed mesad process; transverse striations absent (Fig. 9D). *Epimeral region*: convex immediately anterior to genital valves, but not overhanging them. *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 9F). Aggenital and adanal areas and genital and anal valves reticulate-alveolate, no pores. Genitoanal chaetotaxy 7:1:2:3; genital setae in arcuate file, all except *g7* removed from mesal suture, *g5* and *g6* most so; *g1* in a notch on anterior margin slightly removed from inner anterior corner of valve; *g5* situated at about 0.5 valve length, *g7* inserted anterior to inner posterior corner, not in a notch; setae *ag* inserted at level between *g6* and *g7*; setae *ad1* postanal, *ad2* at or just posterior to posterolateral corner of anal valve, *ad3* level with proximal 0.3–0.4 of anal valve. *Legs*. Distal apophysis of tibia I overlaps about 30% of tarsus. Tarsal cluster of leg I placed distodorsally on a short apophysis, above and slightly proximal to setae *tc*; *ft''* enclosed in its own rim; *omega 1* and *2* slightly ventral to it and enclosed in a separate rim, widely separated and shorter than *ft''* (Fig. 10E), hole (presumably cavity for undeveloped *famulus*) present (Fig. 10E, arrow); tarsus lacking distal recess for receiving retracted unguinal complex, stalk medium length.

**Comments.** The antierad position of setae *ad3*, strongly arcuate placement of genital setae and broad separation of genital and anal vestibules suggest that this species is closely related to *P. propinqua*. It differs in the shape of the intramarginal depression on the notogaster, having an almost perfect oval depression which is not interrupted posteriorly. In *P. propinqua*, the depression is vase-shaped and interrupted posteriorly.

**Etymology.** The specific epithet honours John Bannister, former Director of the Western Australian Museum, who collected the material.

**Distribution.** York area, east of Perth, Western Australia.

### *Pedrocortesella bithongabela* n.sp.

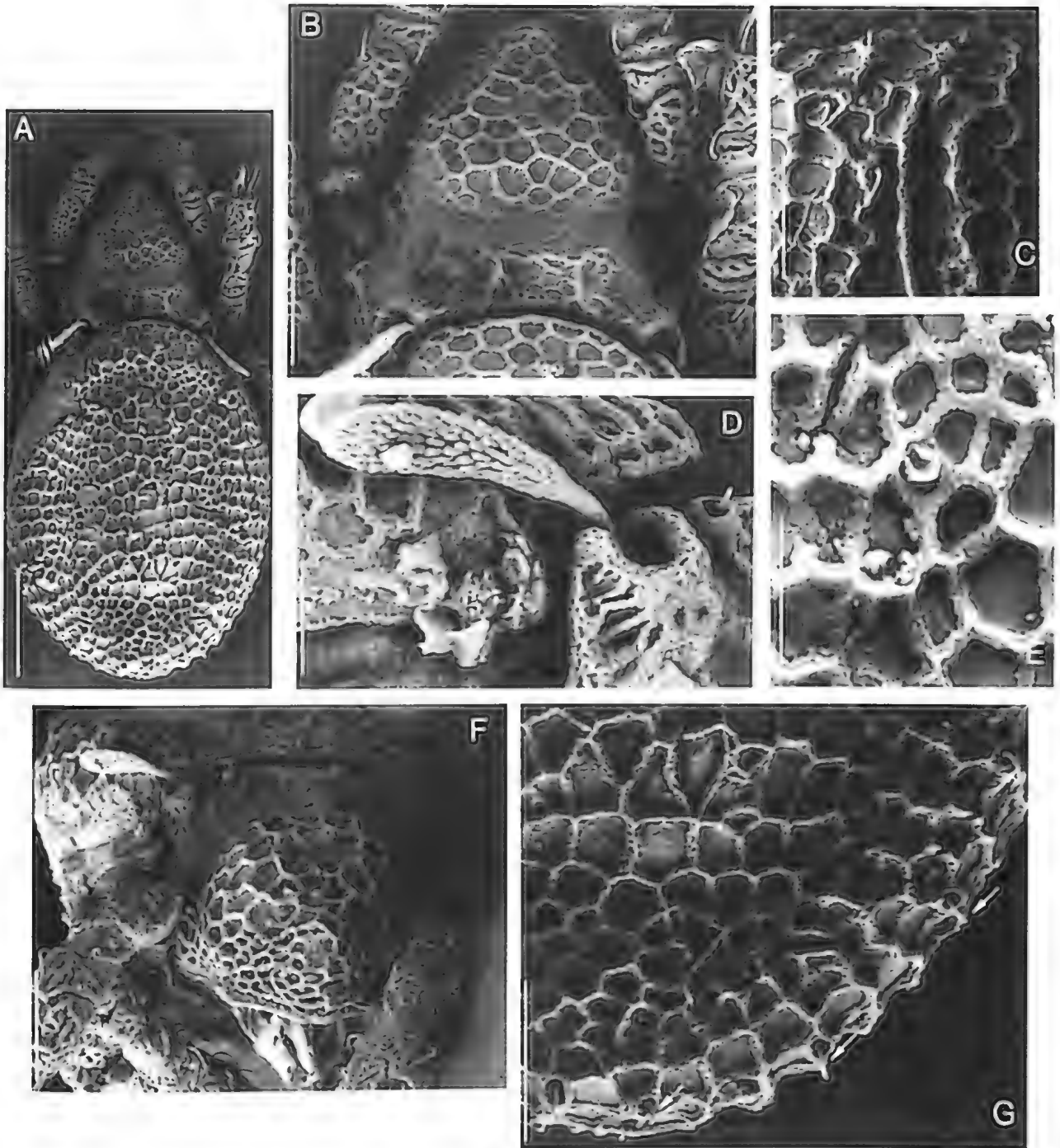
Figs 11, 12, 13B–D

**Type material.** Queensland: HOLOTYPE adult, QM, Mount Bithongabel, Lamington National Park, 28°16'S 153°10'E, *Nothofagus* forest, berlese extraction bark and moss from tree trunks and logs, G.S.Hunt, 14 July 1992. PARATYPE adults. AM KS43685, same data as holotype, 1 adult; AM KS46547, SEM stub no. S/102, same data, 4 adults.

**Diagnosis.** Body medium, length about 450–500 µm; scalps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster strongly reticulate-alveolate; 5 pairs of notogastral setae, arising from pits; genitoanal chaetotaxy 7:1:2:3; genital setae essentially in straight file, insertion of seta *ad3* adjacent to posterior half of anal valve; claw stalk very short.

### Description

**ADULT: Body:** brown; length 465 µm. *Cerotegument*: body with conspicuous network of cerotegument reflecting underlying reticulate pattern of integument (Fig. 11A,B). Setae *ro* and *le* and notogastral setae without obvious cerotegument. *Prodorsum*: integument reticulate, carina between *le* and *ro* absent; *le* dorsal and close to anterior of prodorsum, not arising from large pit, *ro* ventrolateral. Pedotectal tooth similar to *P. propinqua*. Bothridium closely adpressed to notogaster (Fig. 11B), wall semicircular in dorsal view, depressed anterolaterally and largely missing posteriorly, posterolateral carina weak, situated close to notogaster; sensillus length about 0.9 interbothridial distance, with long flattened tuberculate blade (Fig. 11D), posterior margin of prodorsum forming a smooth arc between bothridia. *in* small, set close about 0.5 bothridial diameter from bothridial wall, at edge of dorsosejugal furrow, spiniform (Fig. 11B,D). *Exuvial scalps*: none seen. *Notogaster*: oval, length:width 330:250. Intramarginal depression oval. Notogaster reticulate-alveolate, not perforated by pores (Fig. 11E); posterior margin not invaginate when viewed from above, with a weak carina between setae *p1* when viewed posteriorly (Fig. 11C). Fissura *ia* and *im* subparallel, *ip* perpendicular to sagittal plane; 5 pairs of short notogastral setae arising from small pits, *h1* moderately close, each located just inside posterior margin; *p1* with similar spacing to *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise just inside posterolateral flank, their insertions visible from above, *lp<sub>x</sub>* and *p2<sub>x</sub>* subequidistant from fissura *ip*, *lp<sub>x</sub>* inserted posterior to it (Fig. 11G). *Gnathosoma*: rutella basally with strong concave flexure and moderate buttresses laterally, small pointed mesad processes present, transverse striations absent (Fig. 12C). Pedipalp tarsus setae (*vt*), *l''* and *cm* smooth; apophysis supporting *acm* moderately strong; solenidion reaching beyond base of *acm* (Fig. 12D). *Epimeral region*: strongly convex a small distance anterior to genital valves and not tending to overhang them. *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to



**Fig. 11.** *Pedrocortesella bithongabela* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, notogastral setae *h1* and *p1*, posterior view; D, bothridium, sensillus and seta *in*, anterolateral; E, notogastral integument and fissura *im*; F, prodorsum, frontal; G, part of posterior of notogaster, dorsal, arrows left to right label setae *h1*, *lp*, *p2*, *p3*; Scale bars: A = 100  $\mu$ m; B,E–G = 50  $\mu$ m; C,D = 20  $\mu$ m.

ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 12A). Ventral plate reticulate-alveolate. Genitoanal chaetotaxy 7:1:2:3; genital setae essentially in straight file (Fig. 12F), *g1* subequal to other setae, at anterior corner in marginal notch; *g5* situated at about 0.5 valve length, *g7* inserted well anterior to inner posterior corner in marginal notch; setae *ag* inserted posterior to *g7*; setae *ad1* postanal (Fig. 12E), *ad3* level with posterior half of anal valve. *Legs*. Distal apophysis of tibia overlaps about 30% of tarsus (Fig. 13C). Tarsal cluster of leg 1 placed distodorsally on apophysis, slightly

proximodorsal to setae *tc*; *ft*", *omega 1* and 2 enclosed in well-developed almost circular common rim (Fig. 13B), no partition separating *ft*" from *omega 1* and 2; *ft*" longer than solenidia; terminal setae tend to be flattened with barbs lining their margins; tarsus with slight distal recess for receiving retracted unguitractor complex, stalk very short (Fig. 13C).

**Comments.** This species is most closely related to *P. truncata* but differs in not having a truncate sensillus. The presence of flattened terminal leg setae in this species is a possible adaptation to arboreal life, perhaps

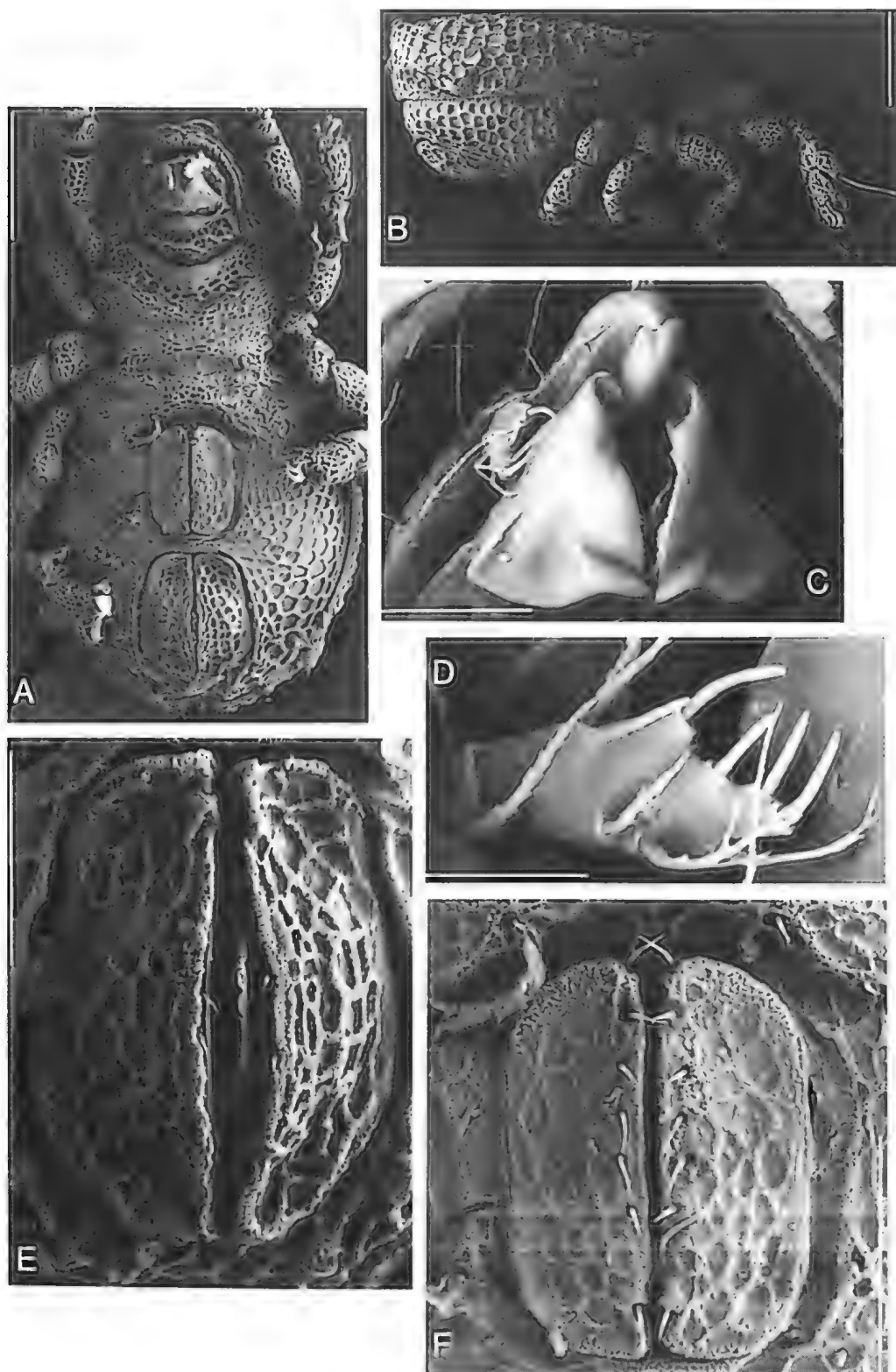


Fig. 12. *Pedrocortesella bithongabela* n.sp. A, body, ventral; B, body, lateral; C, rutella; D, pedipalp tarsus, antiaxial; E, anal valves; F, genital valves. Scale bars: A = 100 µm; E-F = 50 µm; C = 20 µm; D = 10 µm.

enhancing grip. Flattening also occurs in arboreal Hammeriellidae (see Hunt, 1996c), and in the Liodidae whose species are frequently arboreal.

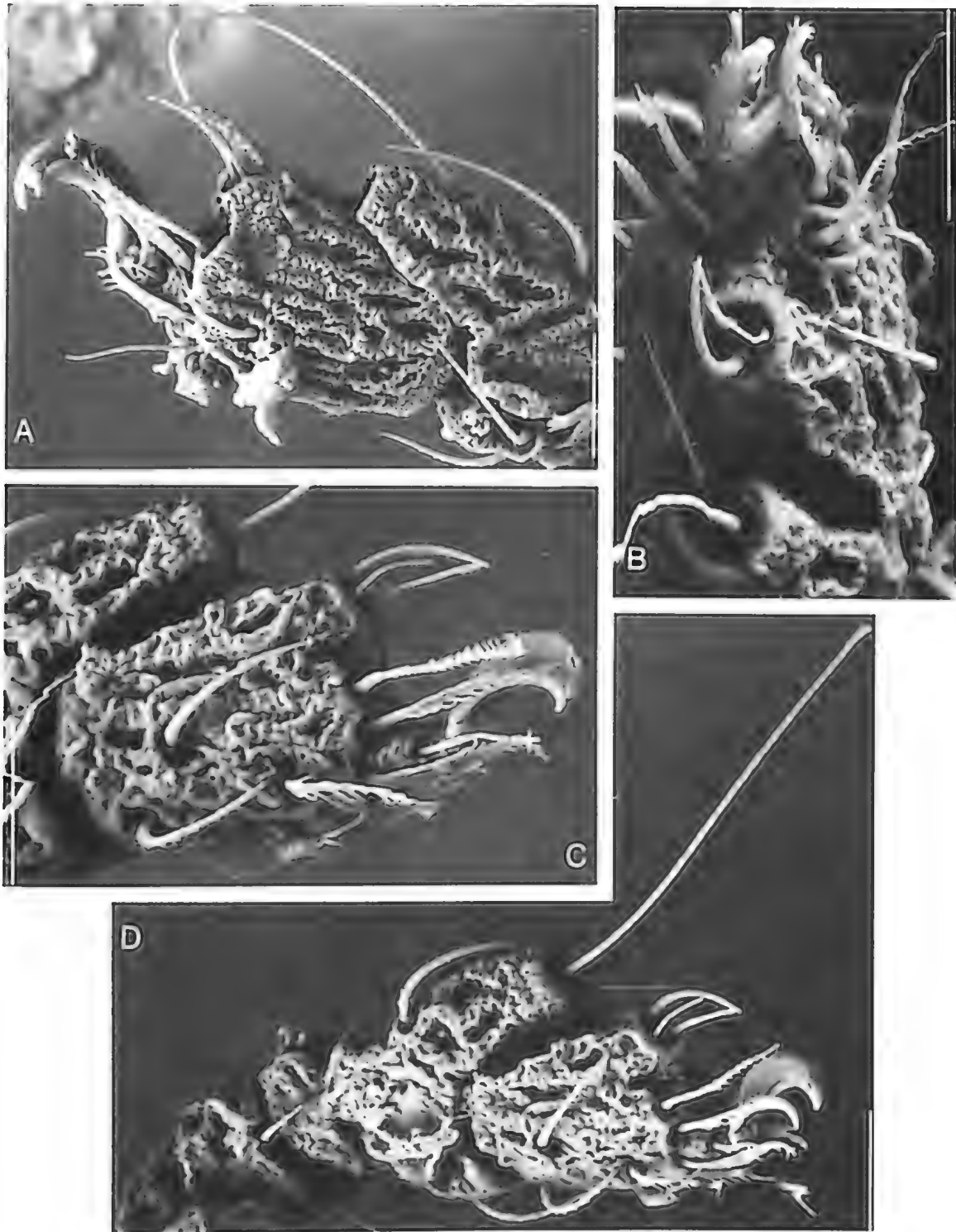
**Etymology.** The specific epithet is the Latinised noun in apposition based on the type locality.

**Distribution.** Lamington National Park, SE Queensland.

*Pedrocortesella callitarsus* n.sp.

Figs 4D-E, 14, 15

**Type material.** South Australia: HOLOTYPE adult, ANIC, 8 km W. of Renmark, 34°13'S 140°41'E, berlese extraction Mallee litter, ANIC berlesate no. 251, I.C. Taplin, 14 May 1970. PARATYPE adults. ANIC, same data as holotype, 3



**Fig. 13.** *Pedrocortesella* spp. Leg I structures. A: *Pedrocortesella truncata* n.sp. A, tibia (distal) and tarsus, antiaxial. B–D: *Pedrocortesella bithongabala* n.sp. B, tibia (distal) and tarsus, dorsal; C, tarsus, antiaxial; D, genu, tibia and tarsus, antiaxial. Scale bars: 20 µm.

adults; AM KS43678, same data, 2 adults; SAMA, same data, 2 adults; AM KS46536, SEM stub no. S/211 (ill.), same data, 3 adults (plus 1 non-type nymph); AM KS46537 SEM stub no. S/218 (ill.), same data, 3 adults; FMNH, same data, 1 adult; CNC, same data, 1 adult.

**Other material examined.** South Australia: AM KS46538, SEM stub no. S/224, 3.6 km E. of Monash, 34°14'S 140°33'E berlese extraction Mallee litter, ANIC berlesate no. 250, I.C. Taplin, 12 May 1970, 1 adult; AM KS46560 SEM stub no. S/217, 6.4 km E. of Paruna, 34°43'S 140°48'E berlese

extraction of Mallee litter, ANIC berlesate no. 240, R.W. Taylor, 8 February 1970, 1 adult; ANIC, Parachilna Gorge, Flinders Ranges, 10 km E. of Parachilna, 31°08'S 138°25'E ANIC berlesate 740, leaf litter at base of *Eucalyptus camaldulensis*, A. Calder, 3 Sept. 1981, 6 adults.

**Diagnosis.** Body medium-large, length about 550–700 µm; scalps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster reticulate-alveolate around margins, punctate centrally; 5 pairs of



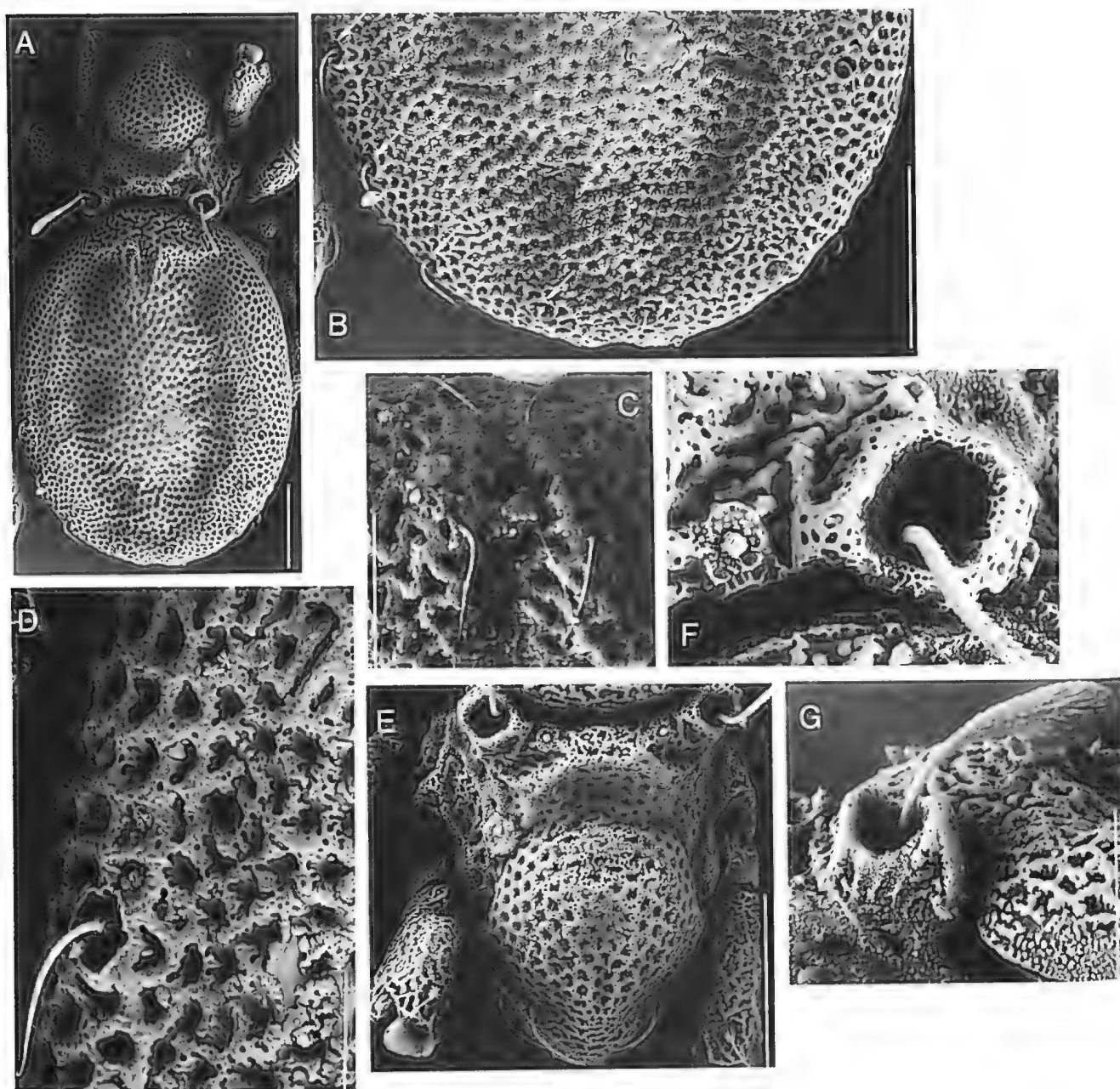


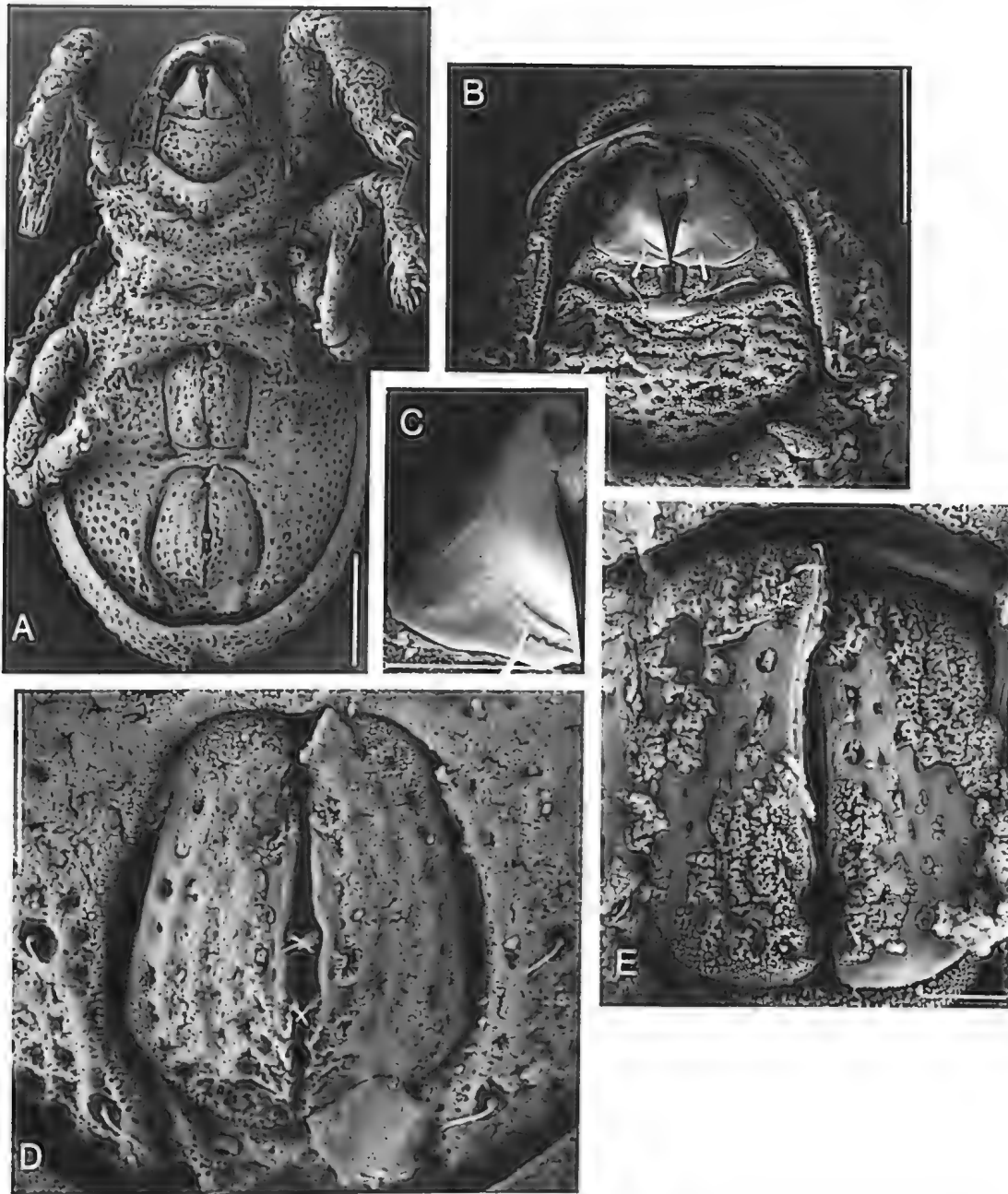
Fig. 14. *Pedrocortesella callitarsus* n.sp. A, body, dorsal; B, notogaster, posterior, dorsal, arrows right to left label setae *h1*, *lp*, *p2*, *p3*; C, notogastral setae *h1* and *p1*, posterior view; D, notogastral integument, fissura *im* and seta *p3*; E, prodorsum, dorsal; F, bothridium and seta *in*, dorsal; G, bothridium, sensillus and seta *in*, lateral. Scale bars: A,B,E = 100  $\mu$ m; D,G = 50  $\mu$ m; C,F = 20  $\mu$ m.

notogastral setae, genitoanal chaetotaxy 7:1:2:3, genital setae essentially in straight file, level of insertion of seta *ad3* adjacent to posterior half of anal valve; claw stalk very short.

### Description

ADULT: *Body*: brown; length ( $\mu$ m) 580, 610, 620, 670. *Cerotegument*: body generally with thin veneer of cerotegument; raised areas on body highlighted by a low encrustation of cerotegument (Fig. 14D). Setae *ro* and *le* and notogastral setae with ribbed accretion of cerotegument near base, though not as marked as *P. hangayi*. Legs with cerotegument capping surface

sculpturing, setae with striking ribbed accretions. *Prodorsum*: integument reticulate-foveolate at rostrum but tends to be punctate more posteriorly; no carina between *le* and *ro*; *le* dorsolateral, distance between them about 0.7 distance between *ro*, *ro* ventrolateral. Pedotectal tooth similar to *P. propinqua*. Bothridium abutting notogaster but not closely adpressed (Fig. 14F), wall subcircular and depressed anterolaterally, posterolateral carina weak, situated close to notogaster; sensillus length about 0.8 interbothridial distance, with long flattened tuberculate blade (Fig. 14G), posterior margin of prodorsum forming a smooth arc between bothridia. *in* small, set  $>0.5 < 1.0$  bothridial diameter from bothridial wall, near edge of dorsosejugal furrow, spiniform but



**Fig. 15.** *Pedrocortesella callitarsus* n.sp. A, body, ventral; B, subcapitulum; C, rutellum; D, anal valves; E, genital valves. Scale bars: A = 100  $\mu$ m; B,D = 50  $\mu$ m; C,E = 20  $\mu$ m.

almost entirely encased in cerotegument (Fig. 14F,G). *Exuvial scalps*: none seen. *Notogaster*: oval, length:width 400:320; 440:330; 440:330; 450:330. Intramarginal depression oval. Notogaster with median groove anteriorly; reticulate-alveolate around margins but punctate centrally (Fig. 14B,D); posterior margin slightly invaginate when viewed from above, without a carina between setae *p1* when viewed posteriorly (Fig. 14C). Fissura *ia* and *im* oblique and *ip* oblique-perpendicular to sagittal plane; 5 pairs of medium lengthed notogastral setae arising from large pits; *h1* widely separated, each located just inside posterior margin; *p1* inserted midheight on posterior flank, slightly further apart than *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise just inside posterolateral flank, their insertions easily visible from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted just posterior to it (Fig. 14B). *Gnathosoma*: rutella basally with strong concave flexure and weak

lateral buttressing, transverse striations present (Fig. 15B,C). Pedipalp not studied. *Epimeral region*: strongly convex immediately anterior to genital valves, tending to overhang them. *Genitoanal region*: separation of anal and genital vestibules relatively narrow with deep transverse grooves and a narrow isthmus between the vestibules (Fig. 15A). Ventral plate punctate. Genitoanal chaetotaxy 7:1:2:3; genital setae essentially in straight file, *g1* slightly longer than other setae, inserted slightly behind anterior corner in marginal notch; *g5* situated at about 0.5 valve length, *g7* inserted well anterior to inner posterior corner, not in marginal notch; setae *ag* inserted at level posterior to *g6*; setae *ad1* distinctly postanal, *ad3* level with posterior half of anal valve; *ad1-3* inserted in large pits. *Legs*. Distal apophysis of tibia overlaps about 30% of tarsus (Fig. 4D). Tarsal cluster of leg I placed distodorsally on apophysis, almost

directly above setae *tc*; *ft*" with base ribbed by thick cerotegument, enclosed in a rim closely abutting rim for *omega* 1 and 2 and sharing a common wall; *ft*" longer than solenidia; tarsus lacking distal recess for receiving retracted unguinal complex, stalk very short.

**Etymology.** The specific epithet means "beautiful tarsus".

**Distribution.** South Australia.

*Pedrocortesella calmorum* n.sp.

Figs 16, 17

**Type material.** Western Australia: HOLOTYPE adult, WAM, 13.5 km N.E. of Crystal Head, S.W. Osborne Island, CALM site 11/1, 14°23'S 125°57'E, rainforest litter, CALM staff, 25–31 January 1989. PARATYPE adults. WAM, 4 km W. of King Cascade, CALM site 28/3, 15°38'S 125°15'E, closed forest litter, ANIC berlesate 1078, T.A. Weir, 12–16 June 1988, 7 adults; AM KS43675, same data, 7 adults; ANIC, same data, 7 adults (plus series of non-type nymphs probably of this species); FMNH, same data, 7 adults; CNC, same data, 7 adults.

**Other material examined.** Western Australia: AM KS46531, SEM stub no. S/162 (ill.), 13.5 km N.E. of Crystal Head, S.W. Osborne Island, CALM site 11/1, 14°23'S 125°57'E, rainforest litter, CALM staff, 25–31 January 1989, 2 adults; AM KS46532, SEM stub no. S/112 (ill.), Camp Creek, 1 km S. of mining camp, Mitchell Plateau, Kimberleys, 14°51'S 125°50'E, ANIC berlesate 875, J. Balderson, 13 May 1983, 1 adult; AM KS46534, SEM stub no. S/151-04 (ill.), Prince Frederick Harbour, "Marun" CALM site 8/4, 15°00'S 125°21'E, closed forest litter, ANIC berlesate 1081, I.D. Naumann, 6–11 June 1988, 1 adult; AM KS43676, same data, 1 adult; AM KS46533, SEM stub no. S/341, Augustus Island, CALM site 26/1, 15°25'S 124°38'E, closed forest litter, ANIC berlesate 1082A, I.D. Naumann, 11–16 June 1988, 1 adult.

**Diagnosis.** Body medium-large, length about 600–700 µm; scalps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster densely reticulate-punctate but lateral margins alveolate, with caudal notch when viewed from above, 5 pairs of notogastral setae; genital and anal vestibules close; genitoanal chaetotaxy 7:1:2:3, genital setae in slightly arcuate file, level of insertion of *ad*3 at about half length of anal valve, adanal setae short; claw stalk short.

**Description**

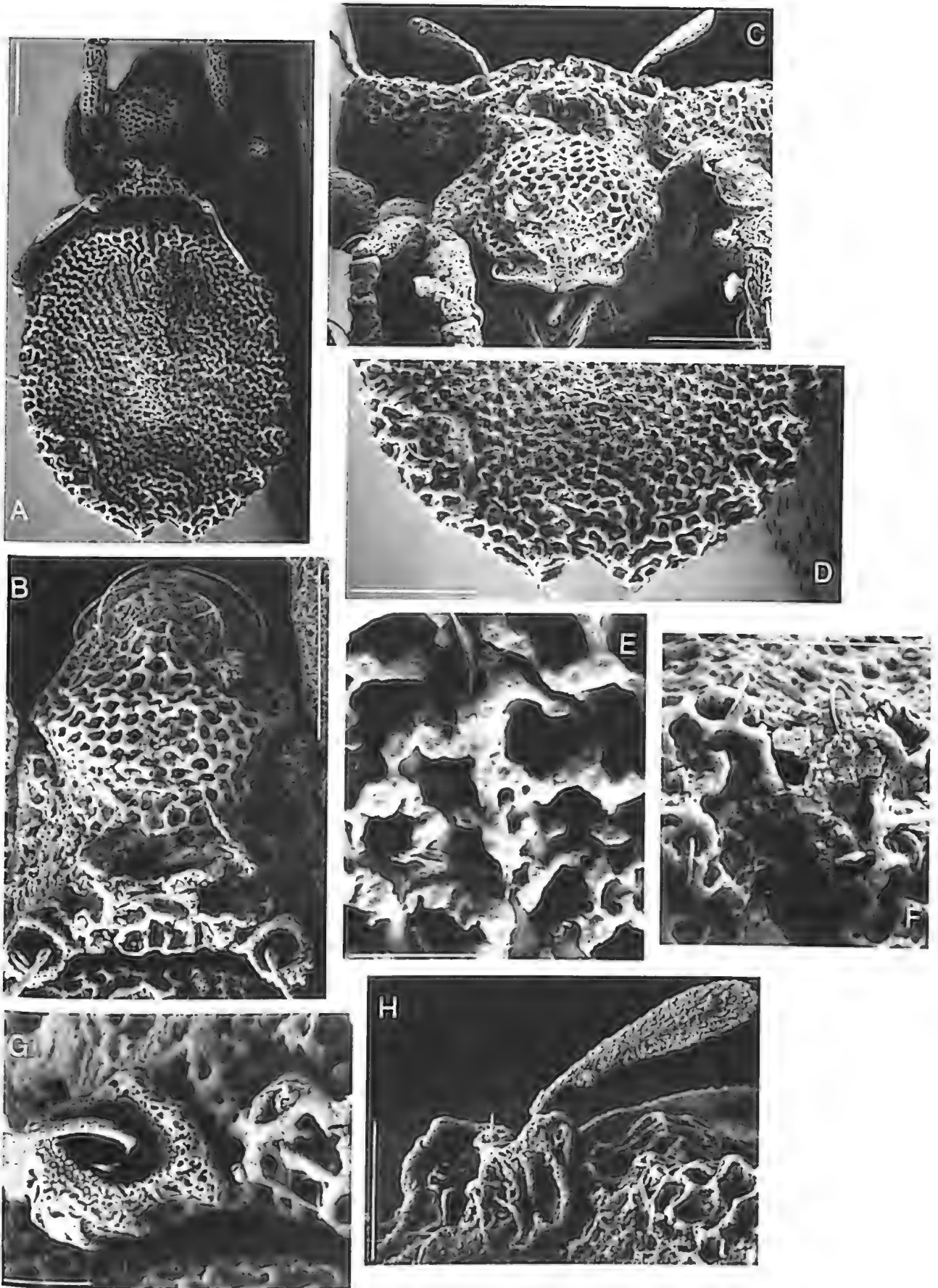
**ADULT:** *Body:* brown; length of 3 specimens from Western Australia 630 µm, 690 µm, 690 µm. *Cerotegument:* body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster and rim of bothridium with a capping of cerotegument. Setae *ro* and *le* and notogastral setae without obvious cerotegument. Legs with cerotegument capping the reticulate surface ornamentation which is of much lower relief than in *P. propinqua*. *Prodorsum:* integument divided into 3 fields: rostral field with loose reticulations and some indication of carina between setae *le* and *ro*; anterior to median transverse groove with very deep foveolae and reticulations of high relief; a bothridial field with prominent reticulated bar between bothridia which rises subvertically from the transverse groove

(Fig. 16H). *le* dorsolateral, distance between them about 0.7 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal tooth similar to *P. propinqua*. Bothridium abutting but not closely adpressed to notogaster (Fig. 16G), wall more rounded than in *P. propinqua*; posterolateral carina weak, situated away from notogaster; sensillus length subequal to interbothridial distance, with long flattened tuberculate blade (Fig. 16H). *in* small, set about 0.5 bothridial diameter from bothridium and away from edge of dorsosejugal furrow level with anterior of bothridium, spiniform but largely encased in cerotegument, set in pit in supporting apophysis (Fig. 16G). *Exuvial scalps:* none seen. *Notogaster:* oval but wide, length:width 470:420, 420:350, 480:400. Intramarginal depression U-shaped, interrupted anteriorly by a raised area continuous with central plateau. Most of dorsum densely reticulate-punctate but lateral margins (and flanks) alveolate (Fig. 16D,E). Posterior margin invaginate when viewed from above, without a mesial carina when viewed posteriorly (Fig. 16F). Fissura short; *ia* not seen in SEM or LM, *im* subparallel-oblique and *ip* oblique to sagittal plane. 5 pairs of notogastral setae; *hl* widely separated, each located inside posterior margin; *p1* inserted high on posterior flank, further apart than *hl*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise inside posterolateral flank, their insertions clearly visible from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted lateral to it (Fig. 16D). *Gnathosoma:* pedipalp tarsus with setae (*vt*) and *l*" with long barbs, *cm* barbs short; apophysis supporting seta *acm* moderate height; solenidium *omega* almost reaching to base of *acm*. Rutella basally with weak concave flexure and lateral buttressing, without pointed mesad process; transverse striations absent (Fig. 17B). *Epimeral region:* strongly convex immediately anterior to genital valves. *Genitoanal region:* separation of anal and genital vestibules relatively narrow with deep transverse grooves and a narrow isthmus between the vestibules (Fig. 17A). Entire venter punctate. Genitoanal chaetotaxy 7:1:2:3; genital setae in slightly arcuate file, *gl* slightly longer than other setae, inserted near inner anterior corner; *g5* situated at about 0.5 valve length, *g7* inserted anterior to inner posterior corner, not in marginal notch; setae *ag* inserted at level posterior to *g6*; adanal setae short, *ad1* distinctly postanal, more so than *P. propinqua*, *ad3* level with about 0.5 length of anal valve. *Legs.* Tarsal cluster of leg I placed distodorsally on apophysis, above and slightly proximal to setae *tc*; *ft*" enclosed in its own rim; *omega* 1 and 2 within a separate rim, widely separated, shorter than *ft*", hole (presumably cavity for undeveloped *famulus*) present; tarsus lacking distal recess for receiving retracted unguinal complex, stalk short.

**Variation.** The posterior margin of the notogaster is weakly invaginate in dorsal view in the Prince Frederick Harbour specimen. Setae *hl* are furthest apart in specimens from Crystal Head.

**Comments.** As well as being close to *P. subula*, this species appears very similar to *P. hardyi* J. Balogh from Wau, Papua New Guinea. This latter species differs in having an adanal seta (probably *ad3*) placed more anteriorly than in *P. calmorum*. According to J. Balogh (1968), *P. hardyi* has only one adanal seta visible. *P.*





**Fig. 16.** *Pedrocortesella calmorum* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, prodorsum, frontal; D, notogaster, posterior, dorsal, arrows right to left label setae *p1*, *h1*, *lp3*, *p2*, *p3*; E, notogastral integument and fissura *im*; notogaster, posterior, dorsal; F, notogastral setae *h1* and *p1*, posterior view; G, bothridium and seta *in*, dorsal; H, bothridium, sensillus and seta *in*, lateral. Scale bars: A–D = 100 µm; E, H = 50 µm; F, G = 20 µm. A, D, F, G = Crystal Head; B, C, H = Mitchell Plateau; E = Prince Frederick Harbour.

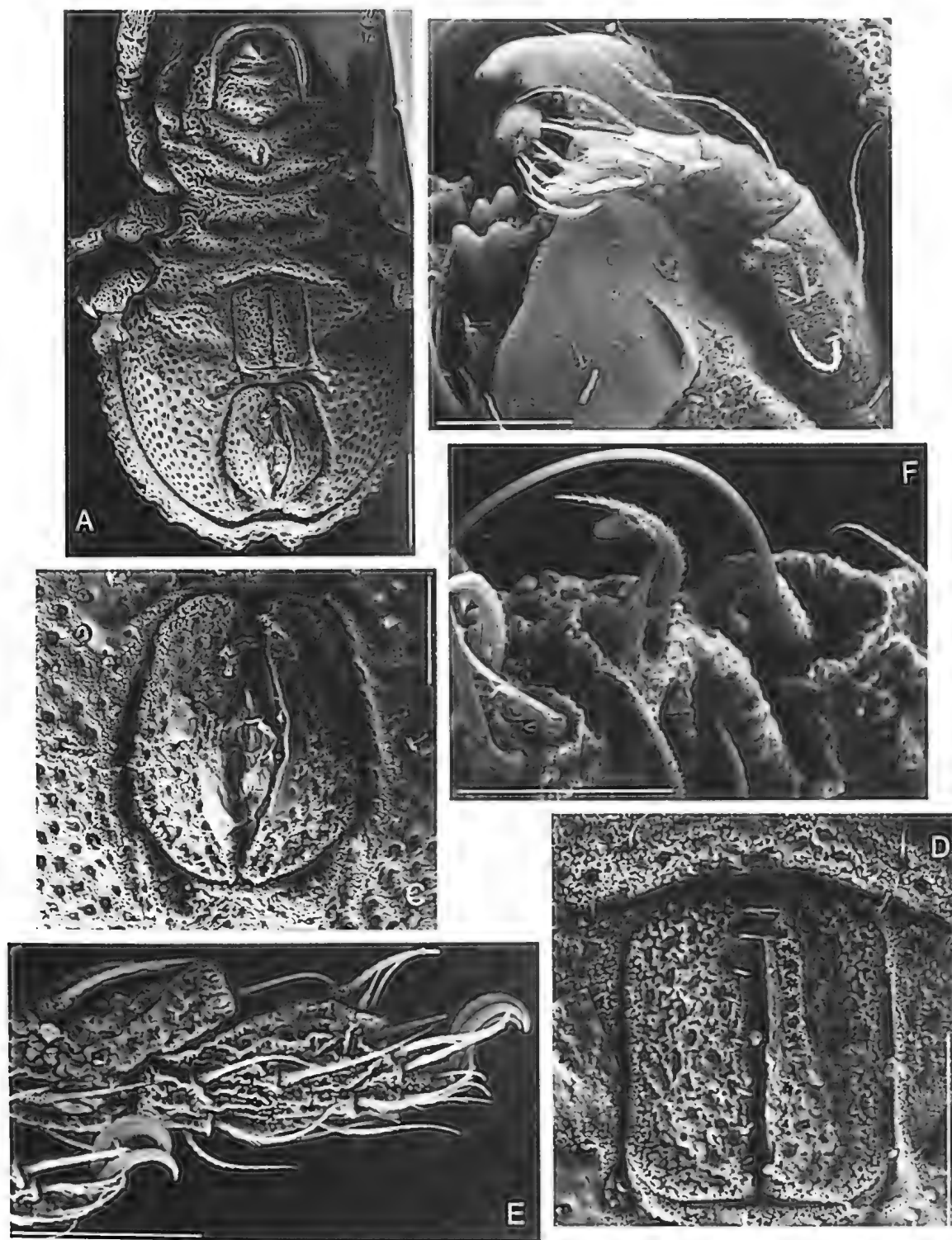


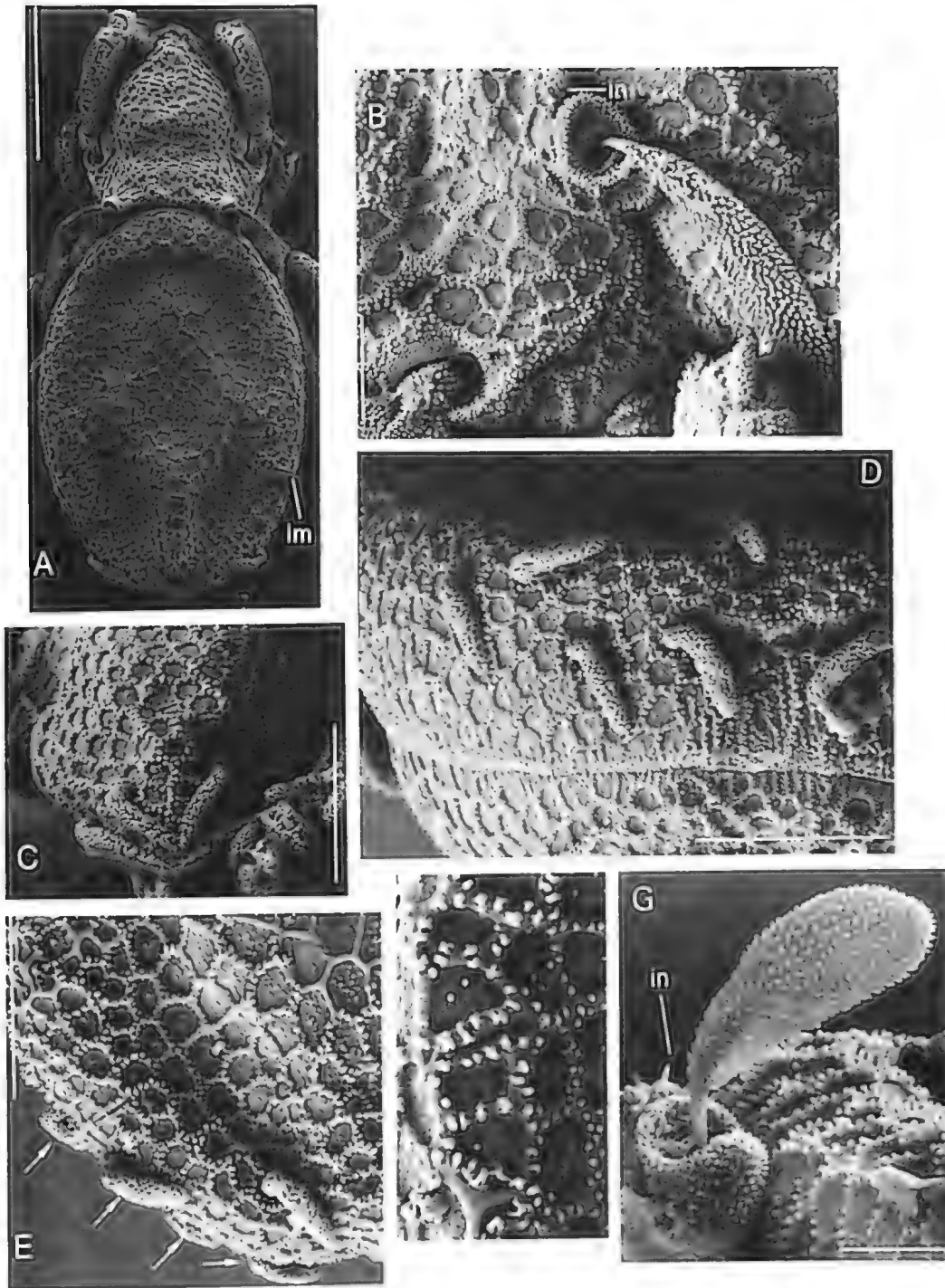
Fig. 17. *Pedrocortesella calmorum* n.sp. A, body, ventral; B, part of gnathosoma with pedipalp, ventrolateral; C, anal valves; D, genital valves; E, leg I, tibia (distal) and tarsus, antiaxial; F, detail tarsal cluster and tibial apophysis. Scale bars: A = 100  $\mu$ m; C-E = 50  $\mu$ m; B, F = 20  $\mu$ m. A-F = Crystal Head.

*calmorum* seems to be also closely related to a species in Japan, probably incorrectly identified and redescribed by Aoki (1984) as *P. hardyi*. This species was also incorrectly transferred to *Pedrocortesella*, which is now recognised as a junior synonym of *Pheroliodes*.

**Etymology.** The specific epithet acknowledges the research effort of the staff of the Western Australian

Department of Conservation and Land Management (CALM).

**Distribution.** Kimberley area, north-western Western Australia.



**Fig. 18.** *Pedrocortesella conundrum* n.sp. A, body, dorsal; B, sensillus, slightly frontal of true dorsal; C, prodorsum (part), frontal; D, notogastral setae, posterior view; E, posterior part of notogaster, dorsal, arrows right to left label setae *h1*, *p1*, *p2*, *lp* and *p3* (*lm* not shown); F, notogastral microsculpture, fissura *im*; G, bothridium, sensillus and seta *in*, lateral. *in* = interlamellar seta *in*; *lm* = seta *lm* (seta broken off on left side). A = specimen from Taree; B–G = specimens from type locality. Scale bars: A = 100  $\mu$ m; C,D = 50  $\mu$ m; B,E,F = 20  $\mu$ m.

***Pedrocortesella conundrum* n.sp.**

Figs 18, 19

**Type material.** New South Wales: HOLOTYPE adult, AM KS SEM stub no. S/296, Allyn River Park near crossing of Allyn River, N. of Salisbury, 32°10'S 151°30'E, subtropical rainforest, berlesate bark scraped from trees, G.S.Hunt, 5 October 1993. PARATYPE adult, AM KS SEM stub no. 419, same data.

**Other material examined.** Graham Osler, a PhD student at Macquarie University, has recently sampled this species from soil beneath the litter layer in forest near Taree, New South Wales (Osler, pers. comm., 1996).

**Diagnosis.** Body small-medium, length about 400–450  $\mu$ m; scalps rarely (if at all) carried by adult; sensillus long flattened tuberculate blade; notogaster reticulate-alveolate, 6 pairs of notogastral setae, 4 pairs posterior

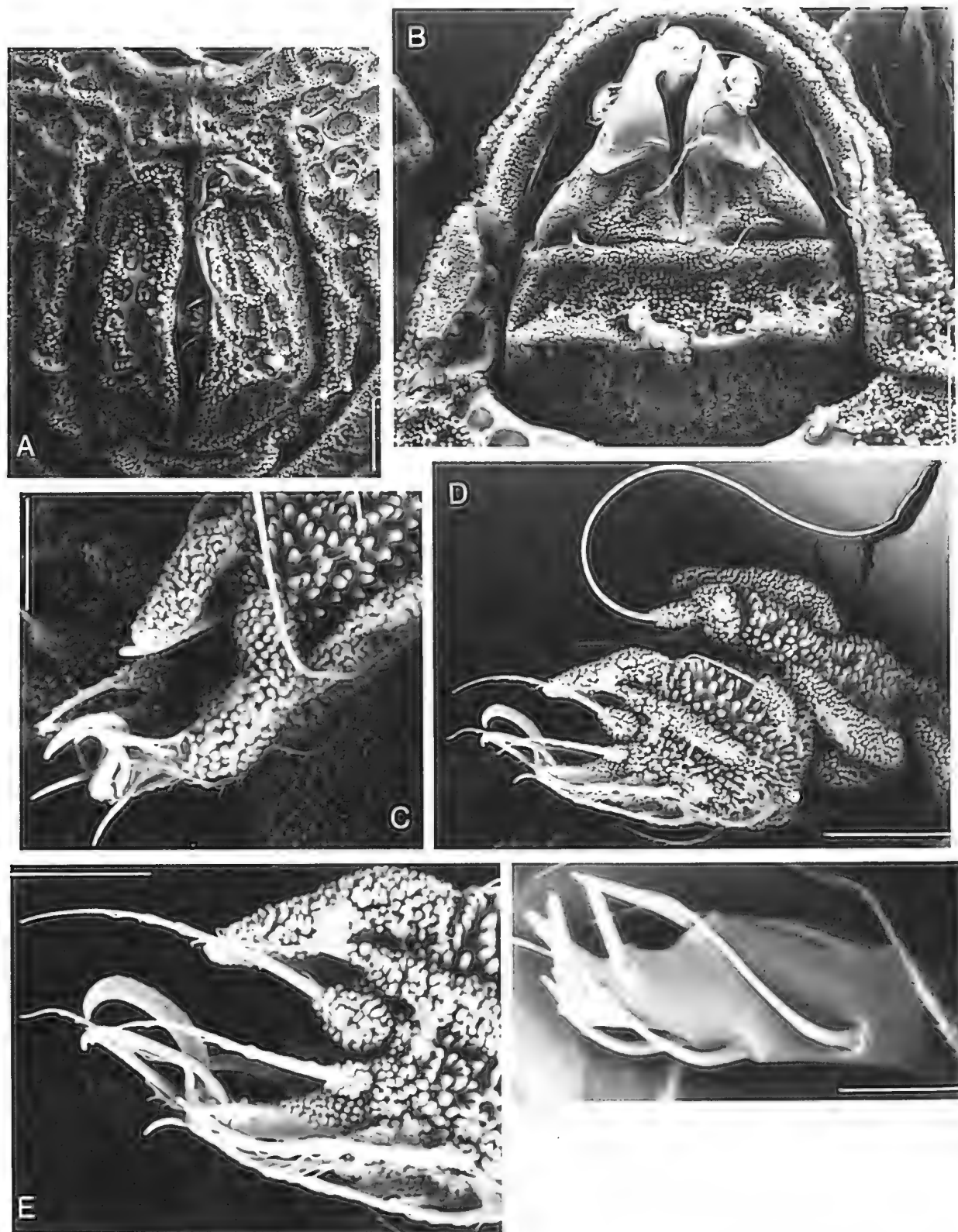


Fig. 19. *Pedrocortesella comundrum* n.sp. A, anal valves; B, subcapitulum; C, distal part of tarsus I, oblique view; D, tibia (distal) and tarsus of Leg I, antiaxial; E, tarsus (distal) of Leg I, antiaxial; F, pedipalp, antiaxial. Scale bars: A,B,D = 20 µm; C,E = 10 µm; F = 5 µm.

to fissura *ip*, seta *p2* at same level on posterior flank as *p1*, *p3* at higher level on posterolateral flank to *p2* but not situated dorsally, genitoanal chaetotaxy 6:1:2-3:2-3, genital setae in straight file, insertion of seta *ad3* adjacent to posterior 50% of anal valve; claw stalk long.

### Description

ADULT: *Body*: brown; length 400 µm, 430 µm. *Cerotegument*: body with cerotegument tubercles and granules highlighting reticulations; alveoli with fewer and smaller granules (Fig. 18E,F). Setae *ro* and *le* and



notogastral setae entirely covered by thick deposit (Fig. 18C,D). *Prodorsum*: integument reticulate-foveate, carina between *le* and *ro* absent; *le* dorsolateral, distance between them about 0.6 distance between *ro*, not arising from large pit, *ro* ventrolateral, its insertion barely seen from above. Pedotectal tooth as in Fig. 18A,B. Bothridium abutting notogaster but not tightly adpressed (Fig. 18A,B), wall subcircular in dorsal view, slightly depressed posteriorly and anteriorly, posterolateral carina very strong, abutting notogaster (Fig. 18G); sensillus length subequal to interbothridial distance, with long flattened tuberculate blade (Fig. 18A,G), posterior margin of prodorsum forming a smooth arc between bothridia. *in* small, set close bothridial wall just inside edge of dorsosejugal furrow, spiniform (Fig. 18A,G). *Exuvial scalps*: none seen. *Notogaster*: oval, length:width 290:210, 300:220. Intramarginal depression oval, interrupted posteriorly. Notogaster centrally with raised area slightly depressed mesally in both specimens (possibly an artefact) (Fig. 18A), reticulate-alveolate, not perforated by pores (Fig. 18A,F); posterior margin not invaginate when viewed from above; without carina between setae *p1* when viewed posteriorly (Fig. 18D). Fissura *ia* subparallel, *im* and *ip* oblique to sagittal plane; 6 pairs of notogastral setae arising from small pits, *h1* widely separated, each located well inside posterior margin; *p1* with similar spacing to *h1*; *p2* at same level on posterior flank as *p1*, *p3* higher on posterolateral flank but still not dorsal; *lp* on posterodorsal flank close to fissura *ip* and inserted posterior to it (Fig. 18E), and *lm* lying dorsally well inside the lateral margin and anterior to fissura *ip*. *Gnathosoma*: rutella basally with weak concave flexure and moderate lateral buttressing, pointed mesad processes and transverse striations absent (Fig. 19B). Pedipalp tarsus with setae (*vt*), *cm* and *l''* smooth; apophysis supporting seta *acm* low; solenidion *omega* reaching to base of *acm* (Fig. 19F). *Genitoanal region*: reticulate-foveate. Separation of anal and genital vestibules broad with little or no interruption of ventral plate microsculpture between the vestibules (Fig. 19A). Genitoanal chaetotaxy 6:1:2-3:2-3; genital setae in arcuate file, most posterior inserted anterior to inner posterior corner, not in marginal notch, seta *ag* at level between *g5* and *g6*; seta *ad1* barely postanal, *ad2-3* arranged around posterior margin of anal valves (Fig. 19A). *Legs*. Cerotegument in form of tubercles, not in reticular pattern (Fig. 19D); tibia I apophysis very strong (Fig. 19C), overhangs about 40% of tarsus. Seta *fi''* completely cloaked in cerotegument, not placed on distinct apophysis or in common rim with solenidia (Fig. 19C,D); stalk long, lateral claws much weaker than central (Fig. 19E).

**Variation.** One specimen from the type locality has two pairs of anal setae, the other has three anal setae on the left side and an unknown number on the right side.

**Comments.** This species resembles *P. kanangra* in the following characters: the presence of six pairs of notogastral setae; in the wide separation of anal and genital vestibules with little interruption to continuity of ventral plate ornamentation; the reticulate-alveolate pattern on the notogaster; the presence of six pairs of genital setae; and the presence of strong ventral keels on leg femora. It differs in the arrangement of notogastral setae, the structure of tarsus I and the slender lateral

claws on the legs. The disposition of notogastral setae in *P. conundrum* is somewhat intermediate between other *Pedrocortesella* species (Fig. 1D), and the condition in *Pheriodes*, which most closely resembles the nymphal arrangement of setae *p1* to *p3* (Fig. 1C). In *P. conundrum*, seta *p2* remains with *p1* but *p3* appears to have partly migrated towards the dorsal surface. Like *P. kanangra*, this species is tentatively placed in *Pedrocortesella*.

**Etymology.** The specific epithet is a noun in apposition referring to the doubtful generic status of this species and the puzzling mix of generic characters.

**Distribution.** Barrington Tops and Taree districts, New South Wales

### *Pedrocortesella enigma* n.sp.

Figs 20, 21

**Type material.** Tasmania: HOLOTYPE adult, ANIC, Mount Victoria, 41°20'S 147°49'E, 900 m, pyrethrum knockdown from trees, H. Mitchell and R. Coy, 25 November 1989; PARATYPE adult, AM KS46642 SEM stub no. S/418 (ill.), Mount Michael, 41°10'S 148°00'E, pyrethrum knock-down from tree, R. Coy, 28 November 1989, 1 adult.

**Diagnosis.** Body length medium, about 540 µm; sensillus terminates in rounded club, not flattened blade; notogaster reticulate-alveolate; 5 pairs long notogastral setae, genitoanal chaetotaxy 7:1:3:3, genital setae in arcuate file, insertion of seta *ad3* adjacent to anterior 50% of anal valve; claw stalk long.

### Description

**ADULT:** *Body*: brown; length 540 µm. *Cerotegument*: body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster with numerous cushion-like grains of cerotegument, some stellate tubercles often coalescing into "stitched" crest (Fig. 20E-F). Setae *le*, *ro* and notogastral setae with tapering basal fringes of cerotegument. *Prodorsum*: integument more or less uniformly reticulate-alveolate including area between bothridia; foveae without visible pores; carina between *le* and *ro* absent; *le* dorsolateral and situated close to anterior of rostrum, distance between them about 0.5 distance between *ro*, not arising from large pit, *ro* ventrolateral, insertion not quite visible from above. Pedotectal tooth strongly curved anteriorly. Bothridium abutting notogaster but not closely adpressed, posterior wall complete, wall diamond shaped as in *P. propinqua* (Fig. 20A,D), posterolateral carina strong, close to notogaster; sensillus clavate and rounded, not with flattened blade, densely tuberculate, length about 0.5 interbothridial distance (Fig. 20B-D); posterior margin of prodorsum forming a smooth arc between bothridia; *in* vestigial, without supporting apophysis; removed from edge of dorsosejugal furrow. *Exuvial scalps*: not seen. *Notogaster*: oval, length:width without scalps 350:300. Intramarginal depression similar in shape to *P. propinqua*. Notogaster strongly alveolate-reticulate, not perforated by pores (Fig. 20D); posterior margin not invaginate when viewed from above, without carina between setae *p1* when viewed posteriorly (Fig. 20F). Fissura *ia* and *ip* oblique to sagittal plane, *im*

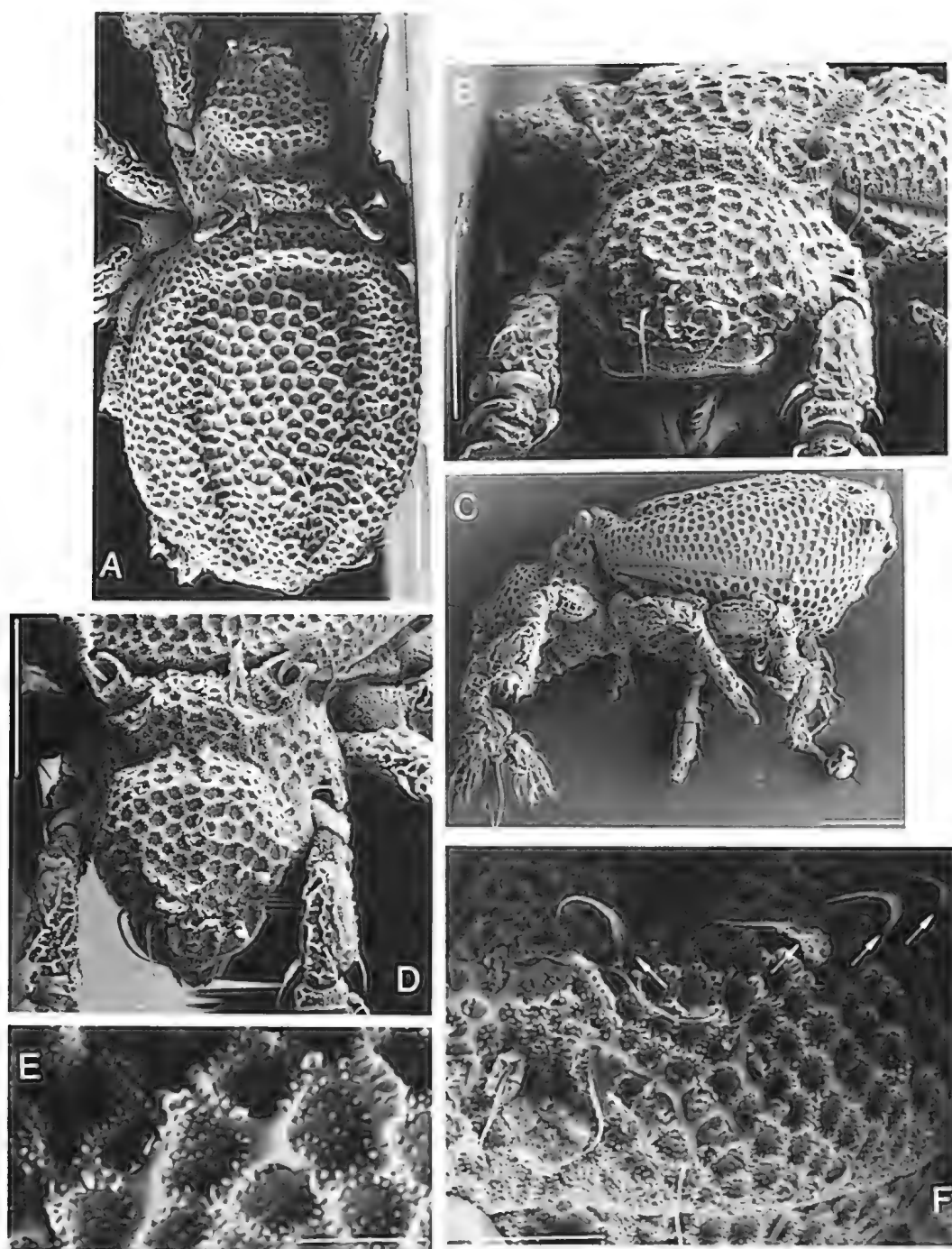
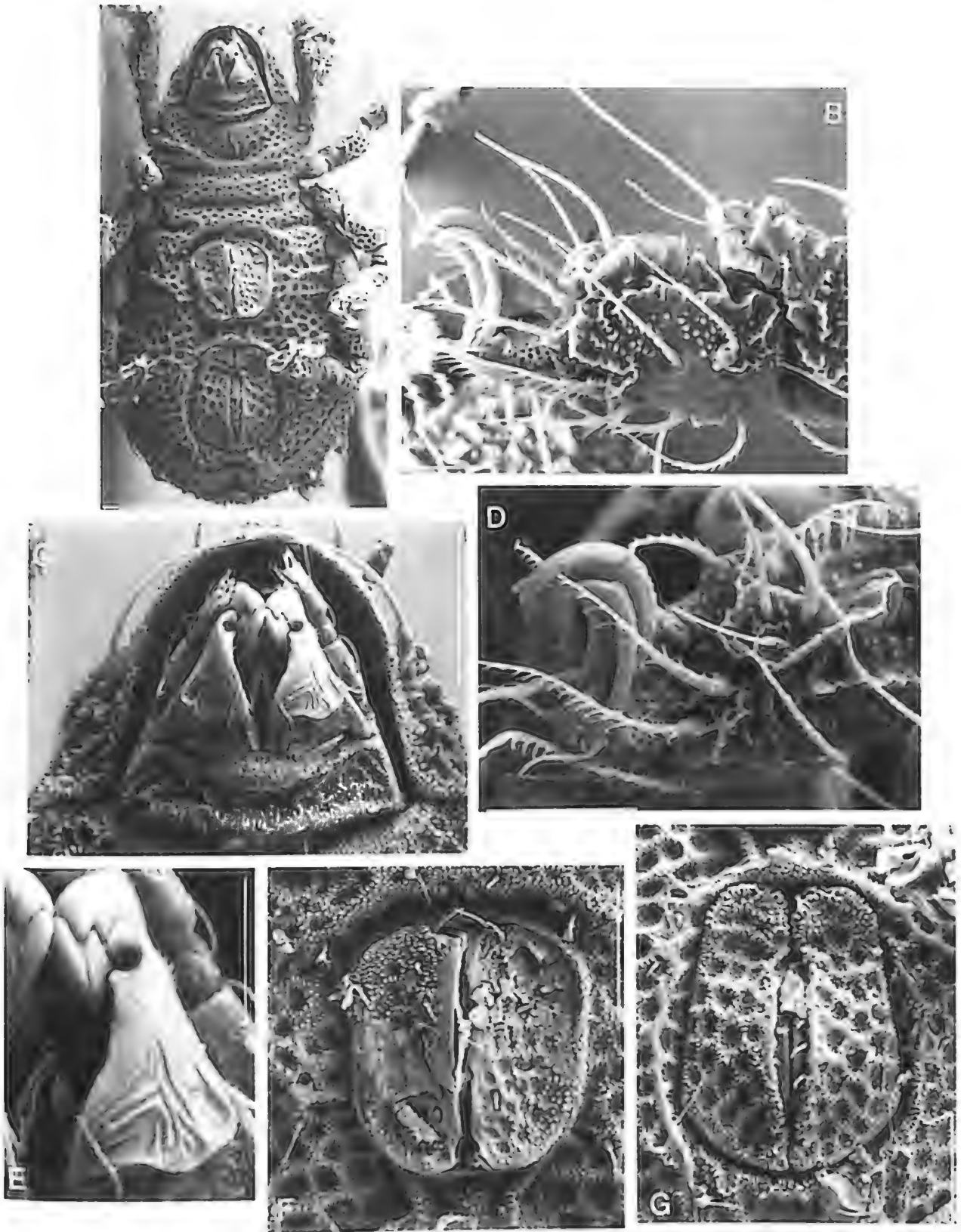


Fig. 20. *Pedrocortesella enigma* n.sp. A, body, dorsal, arrows left to right label setae *h1*, *lp*, *p2*, *p3*; B, prodorsum, frontal; C, body, lateral; D, prodorsum, dorsal; E, notogastral integument; F, notogaster, posterior (part), arrows left to right label setae *p1*, *h1*, *lp*, *p2*, *p3*. Scale bars: A–D = 100  $\mu$ m; F = 50  $\mu$ m; E = 20  $\mu$ m.

subperpendicular; 5 pairs of long notogastral setae (Fig. 20A,F), with thick cerotegument coating at base, not arising from small pits; *h1* moderately separated, each located inside posterior margin; *p1* inserted about mid-height on posterior flank, closer together than *h1*; *lp*, *p2* and *p3* arise along posterolateral flank, their insertions visible from above, *lp* closest to fissura *ip* inserted just posterior to it. *Gnathosoma*: rutella basally with without concave flexure, with strong transverse striations, pointed basal mesad process absent (Fig. 21C,E); pedipalp not examined. *Epimeral region*: moderately convex anterior to genital valves, not tending to overhang them. *Genitoanal region*: separation of anal

and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 21A,G), Ventral plate reticulate-foveate. Genitoanal chaetotaxy 7:1:3:3; genital setae essentially in arcuate file but with *g5* placed about 0.5 valve length; *g1* inserted lateral to inner anterior corner of valve in marginal notch; *g7* inserted at inner posterior corner, in marginal notch; setae *ag* inserted at level between *g6* and *g7*; setae *ad1* distinctly postanal, *ad3* inserted level with anterior 30% of anal valve, subequal to *ad2* in separation from valve. *Legs*. Distal apophysis of tibia overlaps about 30% of tarsus (Fig. 21D). Tarsal cluster



**Fig. 21.** *Pedrocortesella enigma* n.sp. A, body, ventral; B, leg 1 tibia (distal) and tarsus, antiaxial; C, subcapitulum; D, leg 1 tarsus, dorsodistal; E, rutellum; F, genital valves; G, anal valves. Scale bars: A = 100  $\mu$ m; C,F,G = 50  $\mu$ m; B,D,E = 20  $\mu$ m.

of leg 1 placed distodorsally on apophysis, *ft''*, *omega* 1 and 2 enclosed in common rim (Fig. 21D), no partition separating *ft''* from *omega* 1 and 2, latter widely separated; tarsus without distal recess for receiving retracted ungual complex, claw stalk long.

**Comments.** This species strongly resembles *P. propinqua* in many respects: the wide separation of genital and anal vestibules, the arcuate arrangement of genital setae; the anterior position of setae *ad*3; the length and disposition of notogastral setae; the vestigial interlamellar setae; and



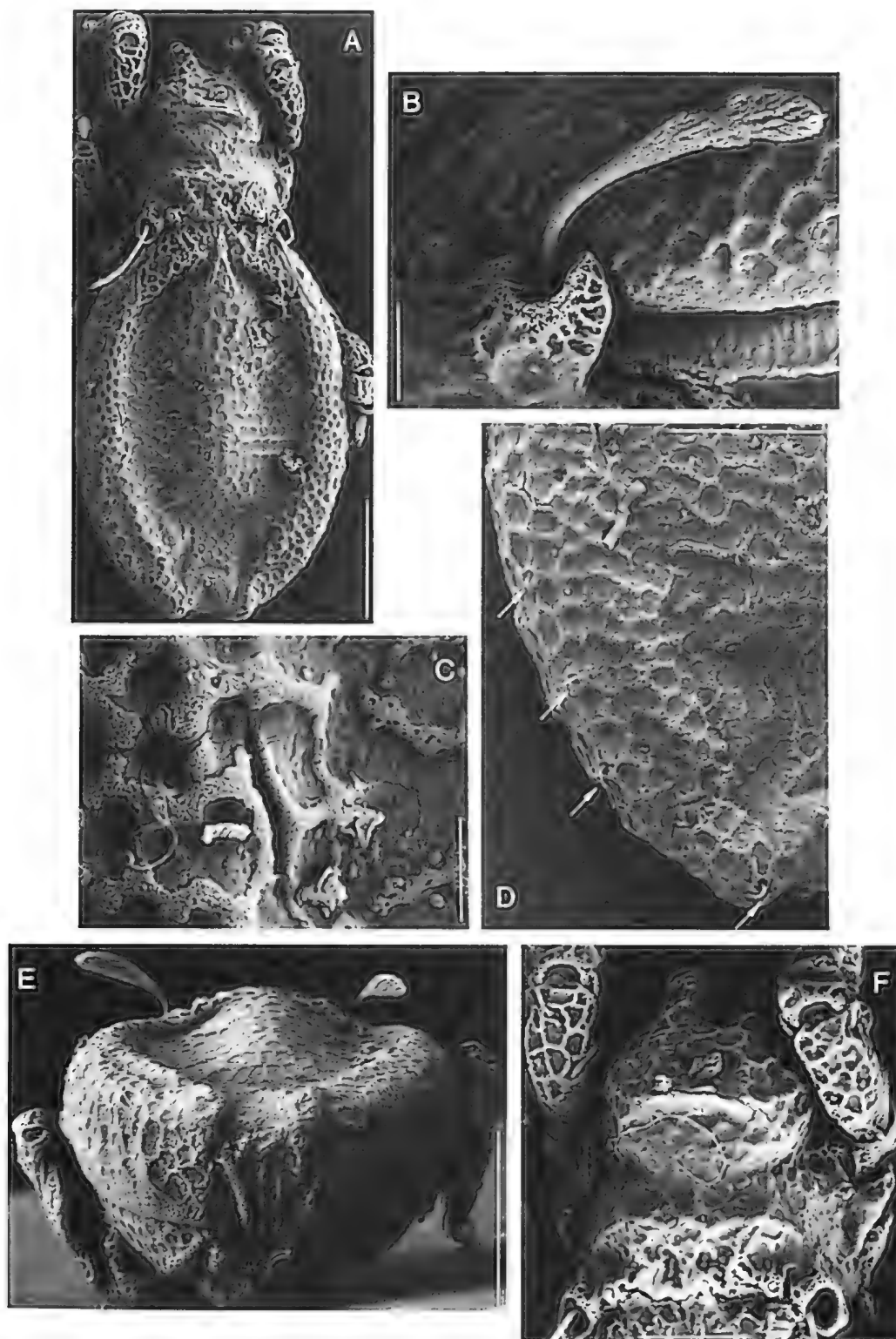


Fig. 22. *Pedrocortesella gunjina* n.sp. A, body, dorsal; B, bothridium, sensillus and tubercle of seta *in* (seta missing), lateral; C, notogastral integument and fissura *im*; D, notogaster, posterior view, dorsal, arrows right to left label setae *h1*, *lp*, *p2*, *p3*; E, notogaster, posterior view; F, prodorsum, dorsal. Scale bars: A, E = 100  $\mu$ m; D, F = 50  $\mu$ m; B = 20  $\mu$ m; C = 10  $\mu$ m.

the shape of the bothridium. It differs in having three pairs of anal setae and a clavate sensillus, the latter being generally regarded as an adaptation to arboreal life (O'Dowd *et al.*, 1991). The species is probably an arboreal representative of the species group suggested for *P. propinqua* and *P. bannisteri* (see General Discussion).

**Etymology.** The specific epithet refers to the puzzling three pairs of anal setae, quite uncharacteristic for *Pedrocortesella*.

**Distribution.** Mountainous rainforest areas, north-eastern Tasmania.

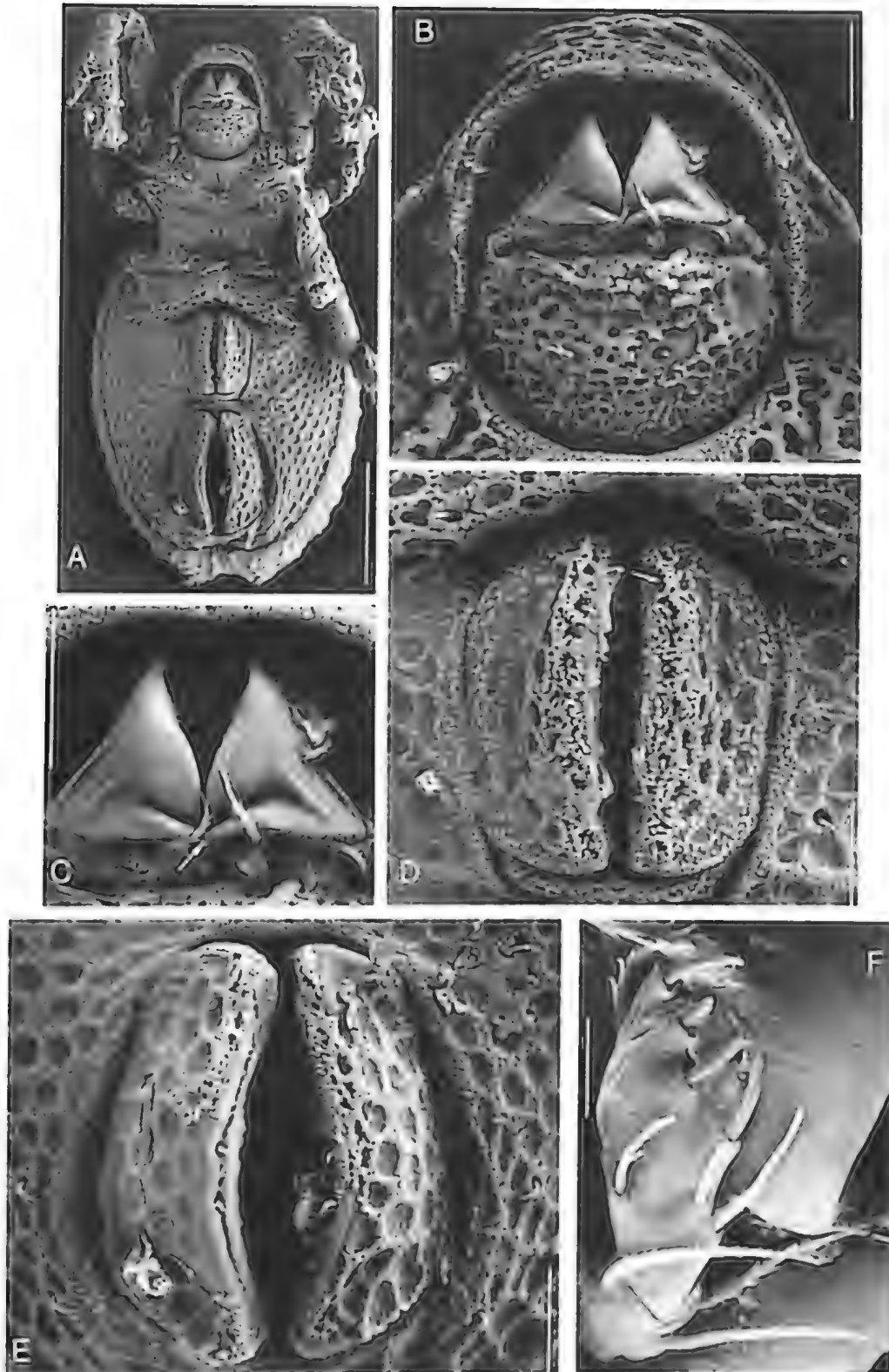


Fig. 23. *Pedrocortesella gunjina* n.sp. A, body, ventral; B, subcapitulum; C, rutella, ventral; D, genital valves; E, anal valves; F, pedipalp, antiaxial. Scale bars: A = 100  $\mu$ m; B–E = 20  $\mu$ m; F = 10  $\mu$ m.

### *Pedrocortesella gunjina* n.sp.

Figs 22, 23, 24C–D

**Type material.** Western Australia: HOLOTYPE adult, WAM, SEM stub no. S/158 (ill.) (specimen mounted on venter, dorsal side up), Gunjin Gully, Hackets Range near Perth, 31°59'S 116°08'E, J.M. Waldock, 27 January 1988. PARATYPE adults. WAM, SEM stub no. S/158 (with holotype), same data, 2 adults.

**Diagnosis.** Body small-medium, length about 400–450  $\mu$ m; scalps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster anterodorsally with mesal carina, reticulate-alveolate, with caudal notch when viewed from above, 5 pairs of notogastral setae, 3 pairs anterior to fissura *ip*; epimera III–IV strongly convex anterior to genital valves and tending to overhang them; genital and anal vestibules close; genitoanal chaetotaxy 7:1:2:3, genital setae in

slightly arcuate file, level of insertion of *ad3* adjacent to posterior half of anal valve; claw stalk long.

### Description

**ADULT:** *Body:* brown; length of type specimens 430  $\mu\text{m}$ , 450  $\mu\text{m}$ . *Cerotegument:* body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster and rim of bothridium highlighted with crests of cerotegument (Fig. 22B–D). Setae *ro* and *le* and notogastral setae without obvious cerotegument. Legs with cerotegument capping the reticulate surface ornamentation which is of much lower relief than in *P. propinqua*. *Prodorsum:* integument reticulate-alveolate, strong transverse carina both anterior and posterior to median transverse groove; no carina between *le* and *ro* though ridge of stronger reticulations at level of *le*; *le* dorsolateral, distance between them about 0.75 distance between *ro*, arising from small pit, *ro* ventrolateral. Pedotectal tooth similar to *P. propinqua*. Bothridium abutting notogaster, (Fig. 22B,F), wall subcircular and depressed anterolaterally, posterolateral carina weak, situated close to notogaster; sensillus with long flattened tuberculate blade (Fig. 22B,E), length subequal to interbothridial distance. *in* small, set about 0.5 bothridial diameter from bothridium near edge of dorsosejugal furrow, spiniform but largely encased in cerotegument (Fig. 22F). *Exuvial scalps:* none seen. *Notogaster:* oval, length:width 330:240. Intramarginal depression oval but interrupted anteriorly but strong mesal carina. Notogaster reticulate-alveolate (Fig. 22A); posterior margin strongly invaginate when viewed from above, with linear ridges rather than mesal carina when viewed posteriorly (Fig. 22E). Fissura *ia* and *im* subparallel and *ip* oblique to sagittal plane; pore to *gla* easily seen posterior to *im*; 5 pairs of short notogastral setae arising from small pits (Fig. 22D), *h1* widely separated, each located just inside posterior margin on slight convexities flanking invagination; *p1* inserted midheight on posterior flank, similar distance apart to *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise just inside posterolateral flank, their insertions visible from above (Fig. 13D), *lp<sub>x</sub>* closest to fissura *ip*, inserted anterior to it (Fig. 22D). *Gnathosoma:* pedipalp tarsus with setae (*vt*) and *l''* with long barbs, *cm* smooth; apophysis supporting seta *acm* moderate height; solenidion *omega* almost reaching to base of *acm*. Rutella basally with strong concave flexure and lateral buttressing, with pointed mesad process (Fig. 23C, arrow); transverse striations absent. *Epimeral region:* strongly convex immediately anterior to and tending to overhang genital valves. *Genitoanal region:* separation of anal and genital vestibules relatively narrow with deep transverse grooves and a narrow isthmus between the vestibules (Fig. 23A). Ventral plate reticulate-alveolate. Genitoanal chaetotaxy 7:1:2:3; genital setae in slightly arcuate file, *g1* subequal to other setae, inserted posterior to inner anterior corner, not in marginal notch; *g5* situated at about 0.5 valve length, *g7* inserted anterior to inner posterior corner, not in marginal notch; setae *ag* inserted at level posterior to *g6*; setae *ad1* distinctly postanal, more so than *P. propinqua*, *ad3* level in posterior half of anal valve. *Legs.* Distal apophysis of tibia overlaps about 50% of tarsus (Fig. 25D). Tarsal cluster of leg I placed distodorsally on apophysis, above and slightly proximal to setae *tc*; *ft''*, *omega 1* and *2* seem to arise from top

of apophysis and not enclosed by distinct rim(s) but some evidence of damage: no distal recess for receiving retracted ungual complex, stalk long.

**Comments.** The strong fold of epimera III–IV which tends to overhang the genital valves suggests that *P. gunjina* is closely related to *P. obesa*, despite the presence of punctations in the notogaster of the latter species.

A single specimen from Coogee, a seaside settlement just south of Perth, is very similar to *P. gunjina*, except that the notogaster is punctate and the prodorsum lacks a transverse carina anterior to the transverse groove. It is somewhat intermediate in morphology between *P. gunjina* and *P. obesa*. It is not assigned to a species in this work.

**Etymology.** The specific epithet refers to the type locality, Gunjin Gully.

**Distribution.** Darling Range, Western Australia.

### *Pedrocortesella hangayi* n.sp.

Figs 24A,B,E, 25, 26

**Type material.** New South Wales: HOLOTYPE adult, AM KS43679, Willandra Homestead via Hillston, 33°12'S 145°07'E, berlese extraction leaf litter near river, G. Hangay and T. Ralph, July 1992. PARATYPE adults. AM KS46539 SEM stub no. S/134 (ill.), same data as holotype, 1 adult; ANIC, 13 km S. of Collarenebri, 29°34'S 148°35'E, berlese extraction *Geijera* leaf litter, ANIC berlesate 88, L.A. Mound, 5 June 1968, 8 adults; AM KS43680, same data, 2 adults; AM KS46540, SEM stub no. S/248 (ill.), same data, 3 adults; FMNH, same data, 2 adults; CNC, same data, 2 adults.

**Diagnosis.** Body medium, length about 500–600  $\mu\text{m}$ ; scalps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster with caudal invagination when viewed dorsally, reticulate-alveolate around margins, more open alveolate-rugose pattern centrally; 5 pairs of notogastral setae arising from large pits, genitoanal chaetotaxy 7:1:2:3, genital setae in arcuate file, insertion of seta *ad3* adjacent to posterior half of anal valve; claw stalk very short.

### Description

**ADULT:** *Body:* dark brown; length 530  $\mu\text{m}$ , 560  $\mu\text{m}$ . *Cerotegument:* body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster and rim of bothridium highlighted with cushion-like masses or crests of cerotegument (Fig. 25E–G). Setae *ro* and *le* and notogastral setae with thick ribbed accretion of cerotegument near base. Legs with cerotegument capping surface sculpturing, setae with striking ribbed accretions. *Prodorsum:* integument reticulate-alveolate particularly anterior to median transverse groove, no carina between *le* and *ro*; *le* dorsolateral, distance between them about 0.65 distance between *ro*, arising from large pit, *ro* ventrolateral. Pedotectal tooth similar to *P. propinqua*. Bothridium abutting but not closely adpressed to notogaster (Fig. 25F), wall subcircular and depressed anterolaterally, posterolateral carina weak, situated close to notogaster; sensillus with long flattened tuberculate blade (Fig. 25E), length about 0.8 interbothridial distance; posterior margin of prodorsum forming a smooth arc between

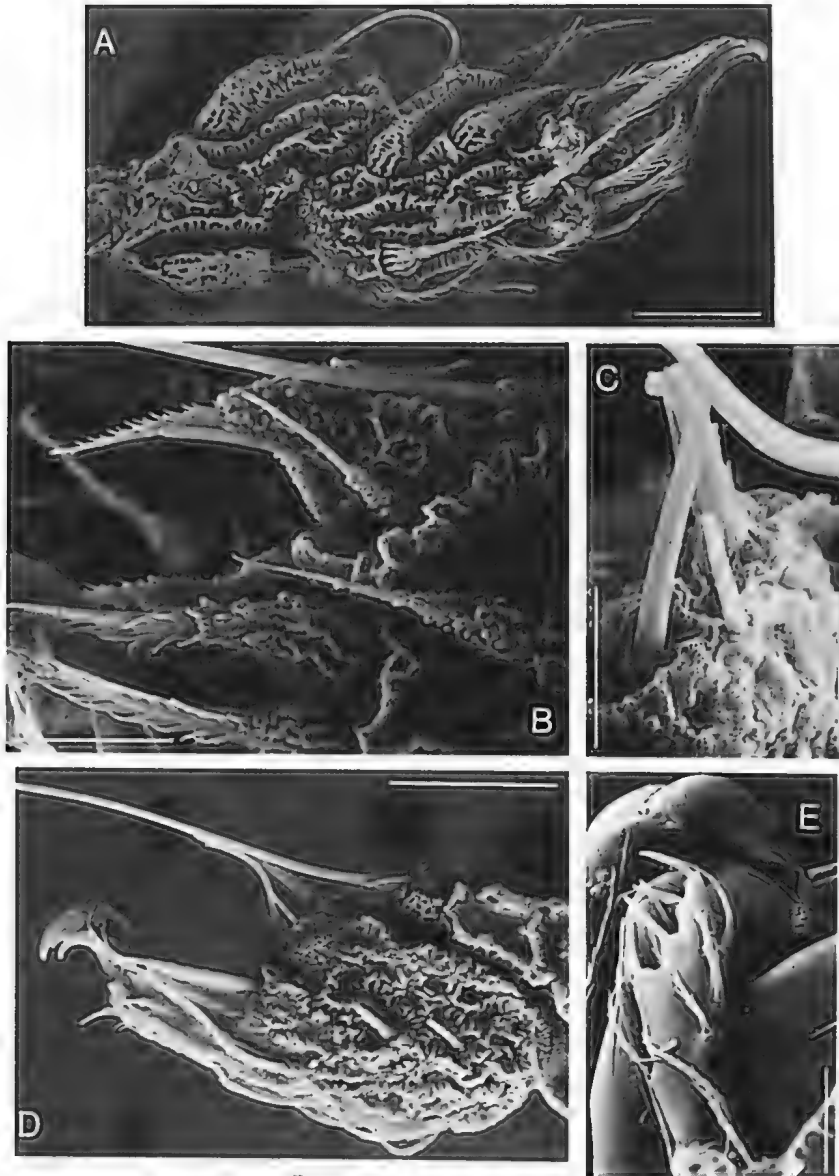


Fig. 24. *Pedrocortesella* spp., appendage structures. A,B,E: *P. hangayi* n.sp. A, leg I tibia (distal) and tarsus, antiaxial; B, detail of tarsal cluster; E, pedipalp. C,D: *P. gunjina* n.sp. C, leg I, tarsus; D, detail of tarsal cluster (damaged). Scale bars: A,C = 20  $\mu$ m; B,E = 10  $\mu$ m; D = 5  $\mu$ m. A,E = Collarenabri; B = Hillston; C = Gunjin Gully.

bothridia. *in* small, set close to base of bothridial wall, at edge of dorsosejugal furrow, entirely encased in cerotegument (Fig. 25F). *Exuvial scalps*: none seen. *Notogaster*: oval, length:width 360:290, 380:295. Intramarginal depression U-shaped. Notogaster reticulate-alveolate around margins but with more open alveolate-rugose pattern centrally (Fig. 25A); posterior margin slightly invaginate when viewed from above, with a V-shaped carina between setae *p1* when viewed posteriorly (Fig. 25D). Fissura *ia* and *im* oblique and *ip* oblique-perpendicular to sagittal plane; pore to *gla* posterior to *im*; 5 pairs of moderately short notogastral setae arising from large pits (Fig. 25D,H); *h1* widely separated, each located just inside posterior margin; *p1* inserted midheight on posterior flank, further apart than *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise just inside posterolateral flank, their insertions easily visible from above, *lp<sub>x</sub>* and *p2<sub>x</sub>* equidistant from fissura *ip*, *lp<sub>x</sub>* inserted posterior to it (Fig. 25H). *Gnathosoma*: cheliceral movable finger ventrolaterally with prominent shelf on antiaxial surface and larger but more flexible flap on paraxial surface. Rutella basally

with strong concave flexure and moderate lateral buttressing, small pointed mesad processes present, transverse striations absent (Fig. 26B). Pedipalp tarsus with setae (*vt*), *l''* and *cm* with medium-short barbs, apophysis supporting seta *acm* short; solenidion *omega* almost reaching to base of *acm*. *Epimeral region*: strongly convex immediately anterior to genital valves, though not tending to overhang them. *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 26A). Ventral plate reticulate-alveolate. Genitoanal chaetotaxy 7:1:2:3; genital setae in arcuate file, *g4* and *g5* furthest away from margin, *g1* slightly longer than other setae, inserted close to inner anterior corner in marginal notch; *g5* situated at about 0.5 valve length, *g7* inserted well anterior to inner posterior corner in marginal notch; setae *ag* inserted at level posterior to *g7*; setae *ad1* distinctly postanal; *ad3* level with posterior half of anal valve; *ad1*–*3* inserted in large pits. *Legs*. Distal apophysis of tibia overlaps



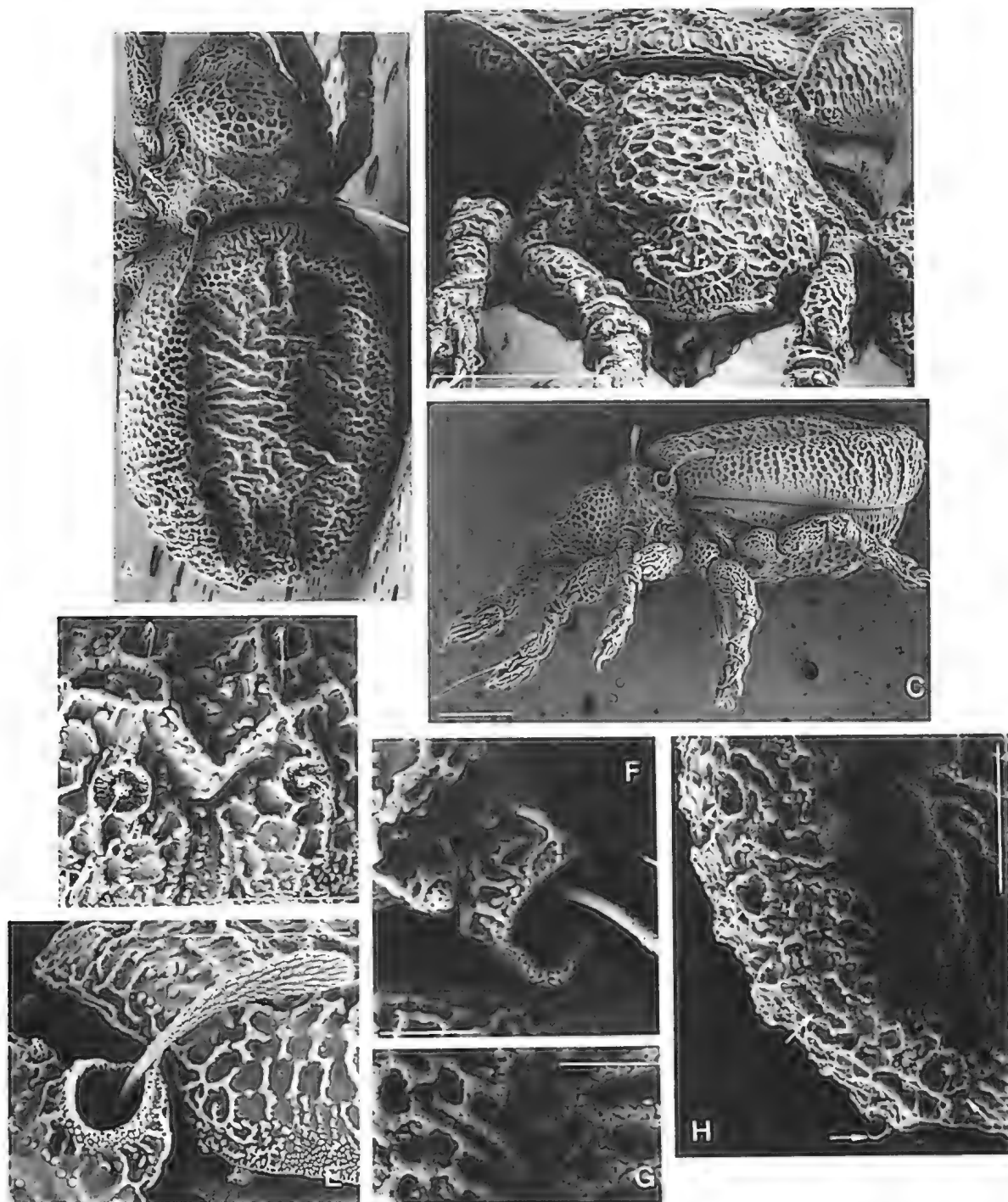


Fig. 25. *Pedrocortesella hangayi* n.sp. A, body, dorsal; B, prodorsum, frontal; C, body, lateral; D, notogastral setae *h1* and *p1*, posterior view; E, bothridium, sensillus and seta *in*, dorsolateral; F, bothridium and seta *in*, dorsal; G, notogastral integument and fissura *im*; H, notogaster, posterior, dorsal, arrows right to left label setae *h1*, *p1*, alveolus of *lp*, (seta broken), alveolus of *p2*, setae *p3*. Scale bars: A–C = 100  $\mu$ m; D,E,H = 50  $\mu$ m; F,G = 20  $\mu$ m.

about 30% of tarsus (Fig. 25A). Tarsal cluster of leg I placed distodorsally on apophysis, almost directly above setae *tc*; *fi* with very thick base ribbed by cerotegument and together with *omega 1* and 2 enclosed in common rim (partition separating *fi* from *omega 1* and 2 not seen); *fi* longer than solenidia; tarsus lacking distal recess for receiving retracted unguinal complex, stalk very short.

**Etymology.** This species is named after George Hangay, a former colleague at the Australian Museum, who

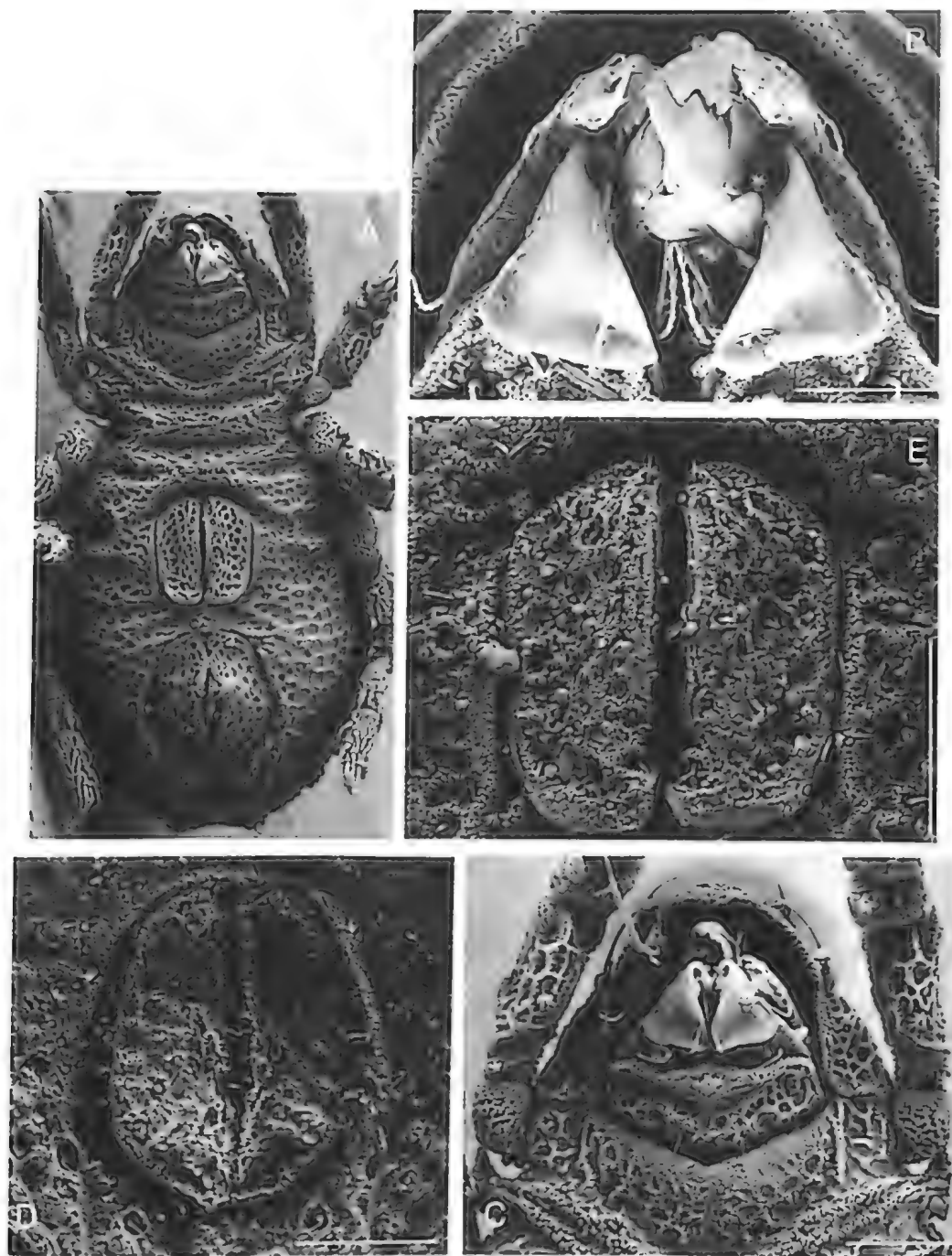
collected the holotype.

**Distribution.** Western New South Wales.

*Pedrocortesella impedita* n.sp.

Figs 27, 28

**Type material.** Western Australia: HOLOTYPE adult, WAM, Mount York, ca 31°53'S 116°48'E, berlesate of she-oak litter, J. Bannister, 16 November 1991. PARATYPE adults. ANIC, same data as holotype, 2 adults; AM KS46541, SEM stub



**Fig. 26.** *Pedrocortesella hangayi* n.sp. A, body, ventral; B, part of gnathosoma: rutella, chelicerae with ventral paraxial and ventral anti-axial processes; C, subcapitulum; D, anal valves; E, genital valves. Scale bars: A = 100  $\mu$ m; C–E = 50  $\mu$ m; B = 20  $\mu$ m. A, B = Hillston; C–E = Collarenebri.

no. S/401 (ill), same data, 3 adults; AM KS46542, SEM stub no. S/420, York, 31°53'S 116°46'E, berlesate Powder bark/Mallee litter, J. Bannister, 2 November 1991, 1 adult.

New South Wales: ZMK, 9.6 km S. of Gilgandra, 31°49'S 148°39'E, dry sclerophyll, ANIC berlesate 89, L.A. Mound, 6 June 1968, 2 adults.

**Other material examined.** New South Wales: ANIC, 13 km S. of Collarenebri, 29°34'S 148°35'E, berlese extraction *Geijera* leaf litter, ANIC berlesate 88, L.A. Mound, 5 June 1968, 1 adult; ANIC, 9.6 km S. of Gilgandra, 31°49'S 148°39'E, dry sclerophyll, ANIC berlesate 89, L.A. Mound, 6 June 1968, 13 adults; AM KS43681, same data, 2 adults; FMNH, same data, 2 adults; CNC, same data, 2 adults; AM KS46543 SEM stub no. S/244, same data, 1 adult.

South Australia: AM KS46501, SEM stub no. S/222, 3.2 km W. Sherlock, ANIC berlesate 182, R.W. Taylor, 12 Jan 1970, 4 adults; AM KS46545, SEM stub no. S/216, 25 km E. by N. of Kimba, 33°05'S 136°41'E litter at base of Mallee, ANIC berlesate 741, A. Calder, 4 Sept. 1981 3 adults.

**Diagnosis.** Body medium, length about 500–600  $\mu$ m; scapulae rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster reticulate-alveolate; 5 pairs of notogastral setae, each arising from a large pit set on a conspicuous mound, genitoanal chaetotaxy 7:1:2:3, genital setae in slightly arcuate file, insertion of seta *ad3* adjacent to posterior half of anal valve; claw stalk very short.

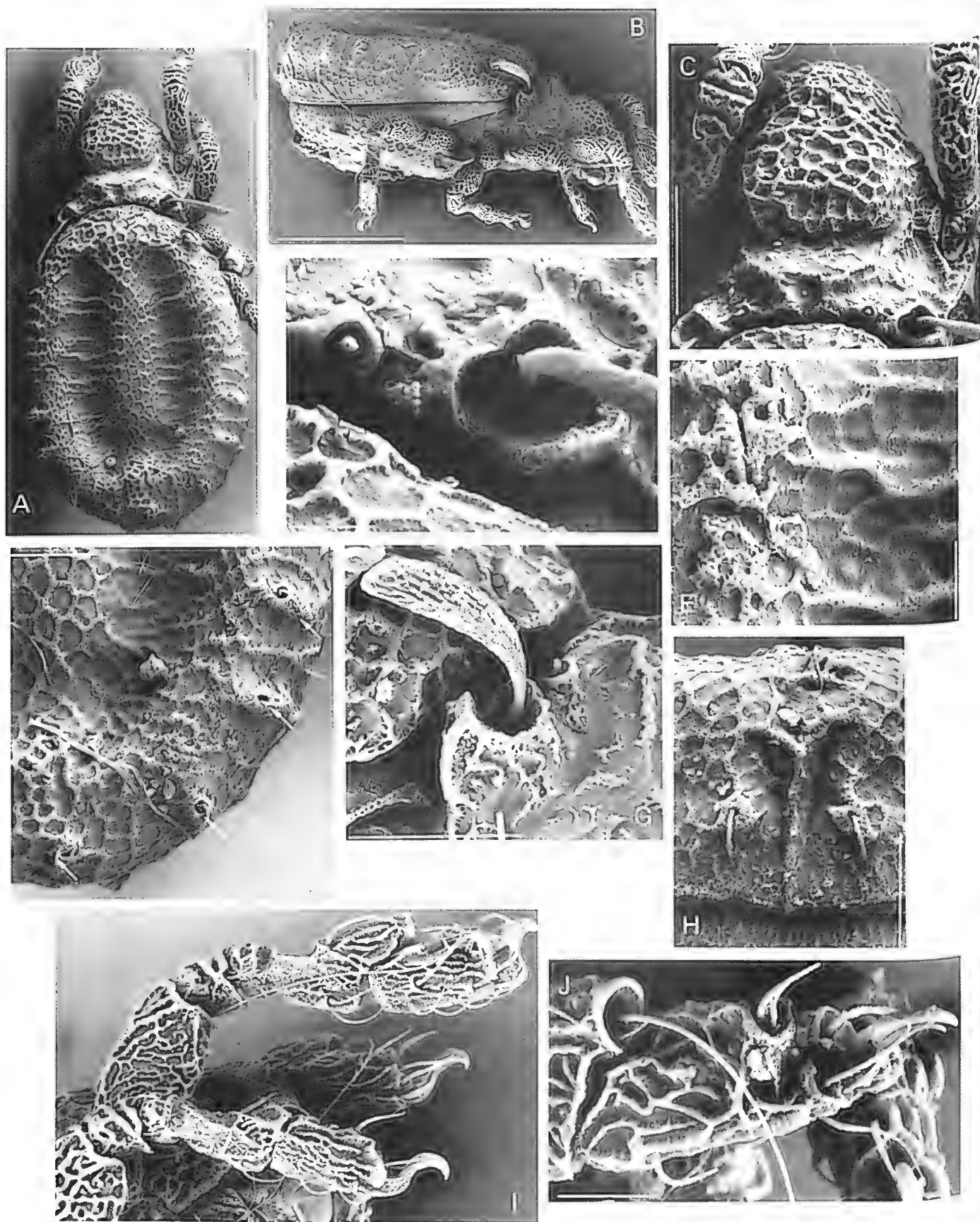


Fig. 27. *Pedrocortesella impedita* n.sp. A, body, dorsal; B, body, lateral; C, prodorsum, dorsal; D, bothridium and seta *in*, dorsal; E, notogastral integument and fissura *im*; F, part of posterior of notogaster, dorsal, arrows left to right label setae *hl*, *lp*, *p2*, *p3*; G, bothridium, sensillus and seta *in*, lateral; H, notogastral setae *hl* and *pl*, posterior view; I, leg I and II, antiaxial; J, leg I tarsus, dorsal. Scale bars: A,B = 200 µm; D,F-I = 50 µm; C,E,J = 20 µm.



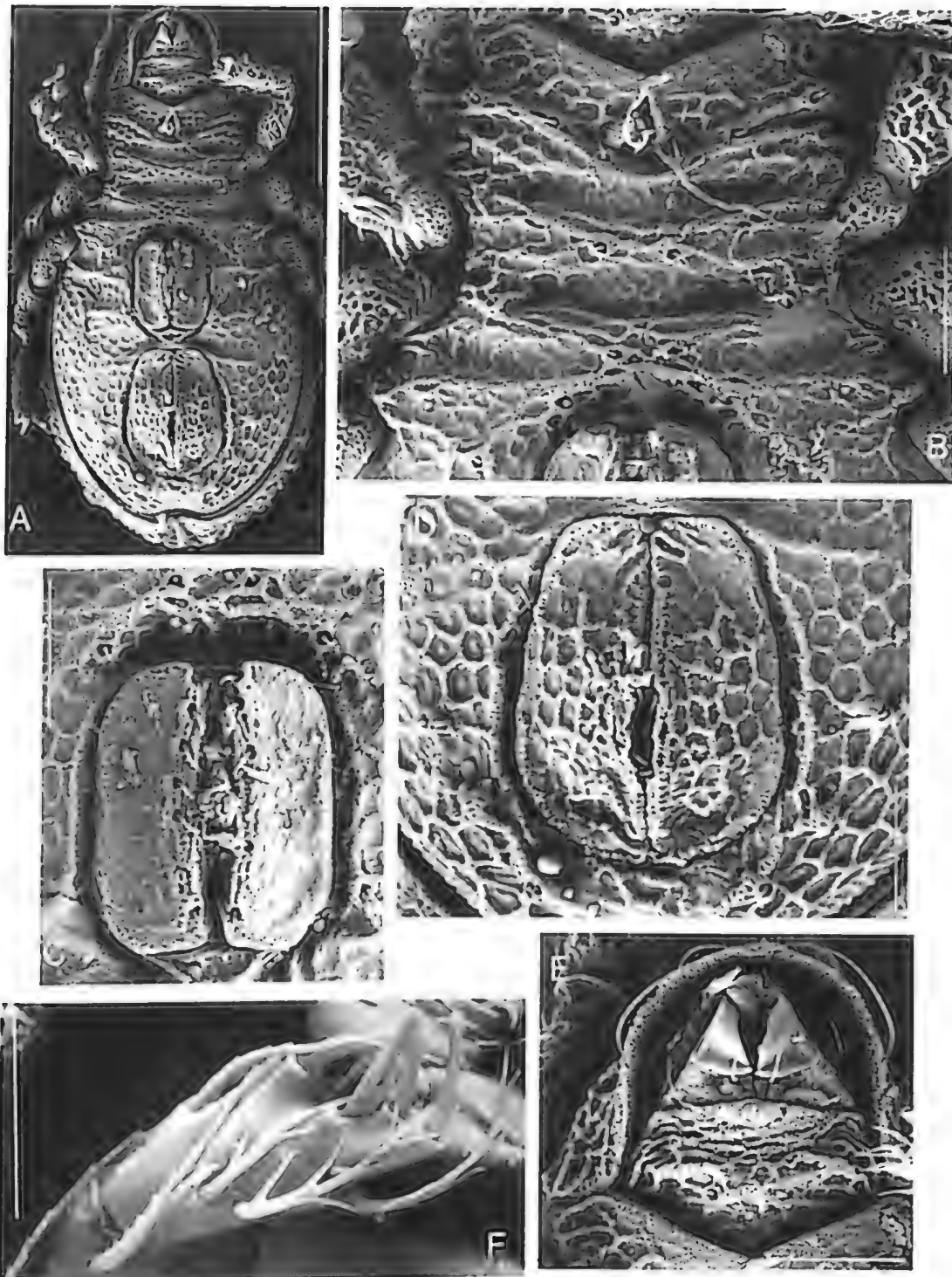


Fig. 28. *Pedrocortesella impedita* n.sp. A, body, ventral; B, epimeral region; C, genital valves; D, anal valves; E, subcapitulum; F, tarsus of pedipalp, antiaxial. Scale bars: A = 200  $\mu$ m; B–E = 50  $\mu$ m; F = 10  $\mu$ m.

### Description

**ADULT: Body:** brown; length 570  $\mu$ m. **Cerotegument:** body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster and rim of bothridium highlighted with crests of cerotegument (Fig. 27C–E). Setae *ro* and *le* and notogastral setae without obvious cerotegument. Legs with cerotegument capping surface sculpturing, setae without obvious cerotegument. **Prodorsum:** integument reticulate-alveolate; no carina between *le* and *ro*; *le* dorsolateral, distance between them about 0.5 distance between *ro*, arising from small pit,

*ro* ventrolateral. Pedotectal tooth similar to *P. propinqua*. Bothridium abutting notogaster (Fig. 27D,G), wall depressed posteromesad, posterolateral carina weak, situated away from notogaster; sensillus length subequal to interbothridial distance, with long flattened tuberculate blade (Fig. 27G), posterior margin of prodorsum forming a smooth arc between bothridia. *in* small, set about 0.5 bothridial diameter from bothridial wall, at edge of dorsosejugal furrow (Fig. 27D). **Exuvial scalps:** very dirty scalps loosely held on Gilgandra specimen (not illustrated). **Notogaster:** oval, length:width 420:300. Intramarginal depression U-shaped. Notogaster reticulate-

alveolate particularly mesally but regular pattern breaking down with horizontal crests predominantly more laterally into alveolate-rugose pattern (Fig. 27A); posterior margin not invaginate when viewed from above, with a carina between setae *p1* when viewed posteriorly (Fig. 27H). Fissura *ia* oblique, *im* and *ip* subparallel to sagittal plane; 5 pairs of moderately short notogastral setae arising from pits atop mounds; *h1* close, each located just inside posterior margin; *p1* inserted low on posterior flank, further apart than *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise just inside posterolateral flank, their insertions easily visible from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted posterior to it (Fig. 27F). *Gnathosoma*: chelicera with prominent shelf ventrolaterally on antiaxial surface of movable finger. Pedipalp tarsus with setae (*vt*) and *l''* with very long barbs, *cm* barbs short; tubercle supporting seta *acm* moderate height; solenidion *omega* reaching to base of *acm* (Fig. 28F). Rutella basally with moderate concave flexure and strong lateral buttressing and with pointed mesad process, transverse striations absent (Fig. 28E). *Epimeral region*: with depressed area immediately anterior to genital valves (Fig. 28B). *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture and with mesal triangular-diamond shaped structure between vestibules (Fig. 28A). Aggenital and adanal areas alveolate-reticulate without pores; genital and anal valves with smaller alveoli of similar depth on both valves. Genitoanal chaetotaxy 7:1:2:3; genital setae in slightly arcuate file (Fig. 28C), but all placed close to mesal suture compared with *P. propinqua*, *g1* of similar size to other setae, inserted in notch at inner anterior corner; *g5* situated at about 0.5 valve length, *g7* inserted well anterior to inner posterior corner; setae *ag* inserted at level just posterior to *g6*; setae *ad1* more postanal than *P. propinqua*, *ad2* about level with posterolateral corner of anal valve, *ad3* level at about 0.5 length of anal valve. *Legs*. Distal apophysis of tibia overlaps about 40% of tarsus (Fig. 27I). Tarsal cluster of leg I placed distodorsally on apophysis, slightly proximodorsal to setae *tc*; *ft''*, *omega 1* and *2* enclosed in well-developed almost circular common rim, no partition separating *ft''* from *omega 1* and *2* (Fig. 27J); *ft''* longer than solenidia; tarsus with distal recess for receiving retracted unguinal complex (Fig. 27J), stalk very short.

**Comments.** *Pedrocortesella impedita* can be mistaken for *P. semireticulata* because of a superficial similarity in notogastral sculpturing. It differs in having seven rather than six pairs of genital setae, but the two species are evidently very closely related. They share the condition of a broad separation of the genital and anal vestibules with a mesal triangular-diamond shaped structure between them. The specimens collected near Sherlock and Kimba, South Australia, were noted by Hunt & Lee (1995) under their description of *P. semireticulata* but not placed in a species.

**Etymology.** The specific epithet is Latin for "embarrassed" and refers to the fact that my technical assistant recognised two species in a sample from Western Australia where I had recognised one.

## *Pedrocortesella kanangra* n.sp.

Figs 29, 30

**Type material.** New South Wales: HOLOTYPE adult, ANIC, Echo Head Falls, Kanangra-Boyd National Park, 33°59'S 150°06'E, 950 m, ANIC berlesate 856, berlese extraction leaf litter near creek, L. Hill, 3 October 1982. PARATYPE adults. AM KS43691, same data as holotype, 1 adult; AM KS46554 SEM stub no. S/240 (ill.), same data, 2 adults; AM KS46555 SEM stub no. S/242 (ill.), same data, 4 adults; AM KS46556 SEM stub no. S/402 (ill.) same data, 1 adult.

**Diagnosis.** Body small-medium, length about 400–450 µm; scalps rarely (if at all) carried by adult; sensillus long flattened tuberculate blade; notogaster reticulate-alveolate, centrally with raised and depressed areas; 6 pairs of notogastral setae, 5 pairs close to posterolateral margin, one mesal pair lower on posterior flank; genitoanal chaetotaxy 6:1:2:3, genital setae in slightly arcuate file, insertion of seta *ad3* near posterior margin of anal valve; leg femora with very strong ventral crest; claw stalk moderately long.

## Description

**ADULT:** *Body*: brown; length 410 µm. *Cerotegument*: body with cerotegument reflecting underlying reticulate pattern of integument, hollowed areas of notogaster tend to have cushions of cerotegument on the reticulations, higher areas continuous crests. Setae *ro* and *le* with thick reticulated crust of cerotegument especially at base (Fig. 30A,C), notogastral setae thickly covered (Fig. 29E). *Prodorsum*: integument reticulate, carina between *le* and *ro* absent; *le* dorsolateral, distance between them about 0.8 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal tooth similar to *P. propinqua*. Bothridium tightly adpressed to notogaster (Fig. 29D), wall triangular in dorsal view, strongly depressed posteriorly, posterolateral carina moderately strong, abutting notogaster; sensillus length subequal to interbothridial distance, with long flattened tuberculate blade (Fig. 29C), posterior margin of prodorsum forming a smooth arc between bothridia. *in* small, set close bothridial wall, at edge of dorsosejugal furrow, spiniform (Fig. 29C,D). *Exuvial scalps*: none seen. *Notogaster*: oval, length:width 310:250. Intramarginal depression oval. Notogaster centrally with raised areas in form of a "Cross of Lorraine" (Fig. 29A), reticulate-alveolate, not perforated by pores (Fig. 29A,F); posterior margin not invaginate when viewed from above; without carina between setae *p1* when viewed posteriorly (Fig. 29E). Fissura *ia* and *ip* subparallel, *im* perpendicular to sagittal plane; 6 pairs of notogastral setae arising from small pits, *h1* moderately close, each located just inside posterior margin; *p1* with similar spacing to *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>*, *p3<sub>x</sub>* and *lm* arise just inside posterolateral flank, their insertions visible from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted lateral to it (Fig. 29F). *Gnathosoma*: pedipalp not studied. *Epimeral region*: strongly convex a small distance anterior to genital valves and not tending to overhang them. *Genitoanal region*: reticulate-alveolate. Separation of anal and genital vestibules broad with little or no interruption of ventral plate microsculpture between the vestibules (Fig. 30F). Genitoanal chaetotaxy 6:1:2:3;

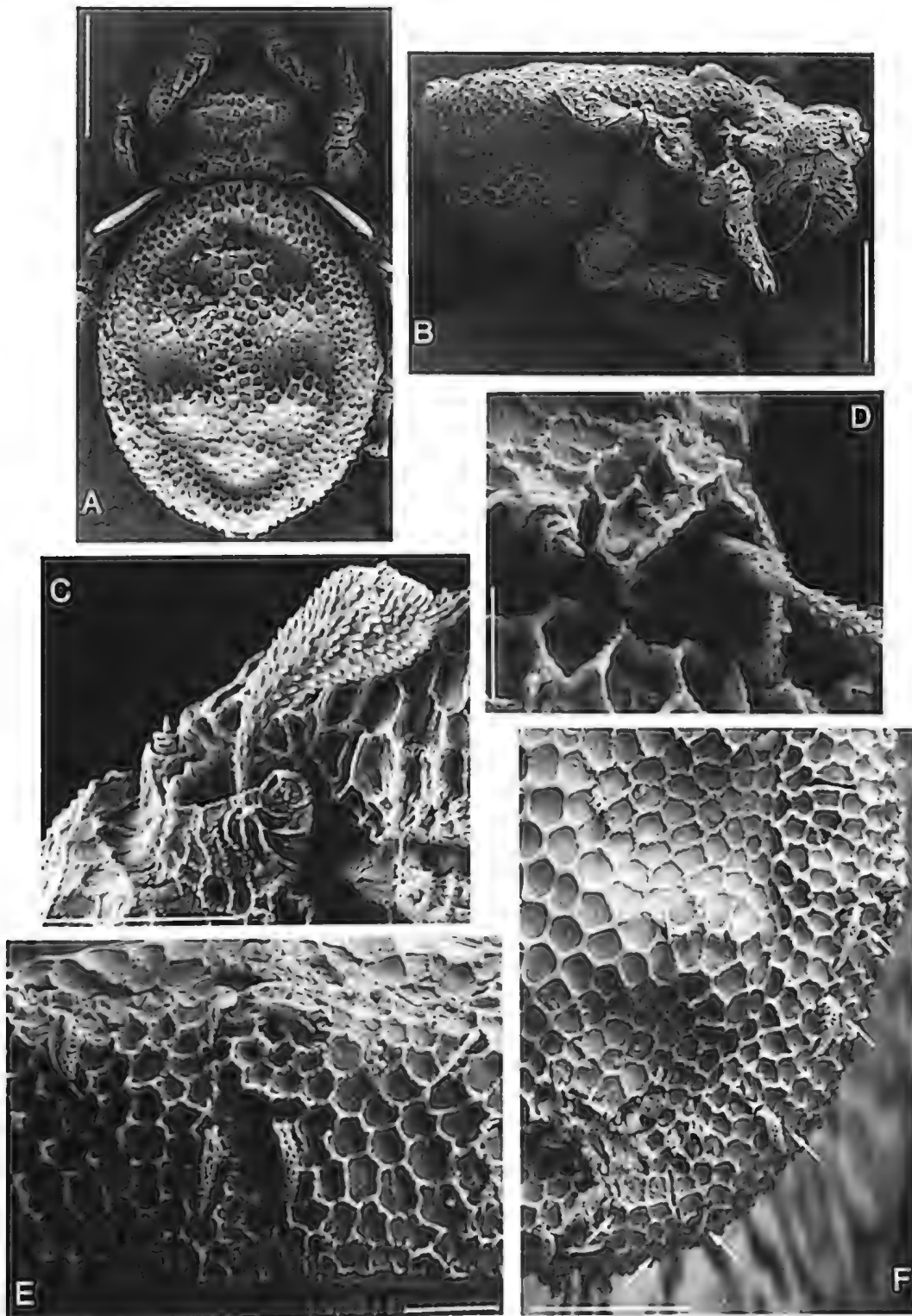
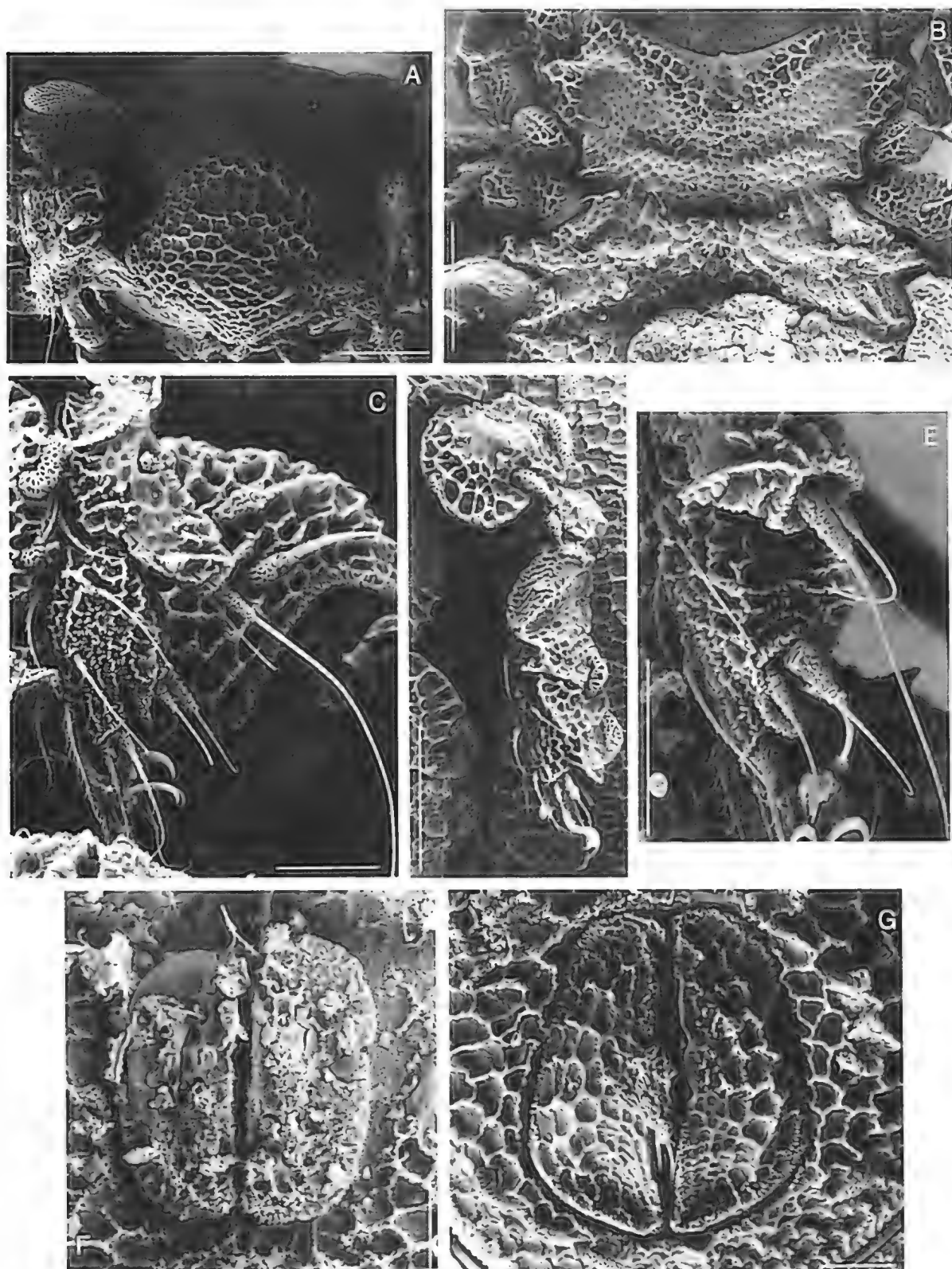


Fig. 29. *Pedrocortesella kanangra* n.sp. A, body, dorsal; B, body, lateral; C, bothridium and seta *in*, lateral; D, bothridium and seta *in*, dorsal; E, notogastral setae *hl*, *pl*, and *lp1*, posterior view; F, notogaster, posterior, dorsal, arrows left to right label setae *hl*, *pl*, *lp1*, *p2*, *p3*, *lm*. Scale bars: A,B = 100  $\mu$ m; F = 50  $\mu$ m; C-E = 20  $\mu$ m.

genital setae in arcuate file, most posterior inserted anterior to inner posterior corner, not in marginal notch (Fig. 30F), seta *ag* at about level of *g6*; seta *ad1* distinctly postanal, *ad2-3* arranged around posterior margin of anal valves. *Legs*. Leg femora with very strong ventral crest giving femur almost circular appearance in lateral view (Fig. 30D); tibia I apophysis very strong (Fig. 30C), overhangs about

40% of tarsus. Tarsal cluster of leg I placed distodorsally on apophysis, well proximodorsal to setae *tc*; *ft*", *omega 1* and 2 enclosed in common rim which is produced into a distal lip (Fig. 30C,E), no partition separating *ft*" from *omega 1* and 2; setae including solenidia with encrusting cerotegument at base; tarsus without distal recess for receiving retracted ungual complex, stalk moderately long.



**Fig. 30.** *Pedrocortesella kanangra* n.sp. A, prodorsum, frontal; B, epimeral region; C, leg I tibia and tarsus, antiaxial; D, leg IV, antiaxial; E, leg I tibia (distal) and tarsus, dorsal; F, genital valves; G, anal valves. Scale bars: A,B,D = 50 µm; C,E–G = 20 µm.

**Comments.** This species appears to be closely related to *P. conundrum* but differs in the distribution of notogastral setae, the pattern of raised areas on the notogaster, in details of leg structure and in the form of cerotegument on the legs. This species is tentatively placed in *Pedrocortesella*.

**Etymology.** The specific epithet is a noun in apposition referring to Kanangra Walls, located near the type locality.

**Distribution.** Known only from the type locality in south-eastern New South Wales.



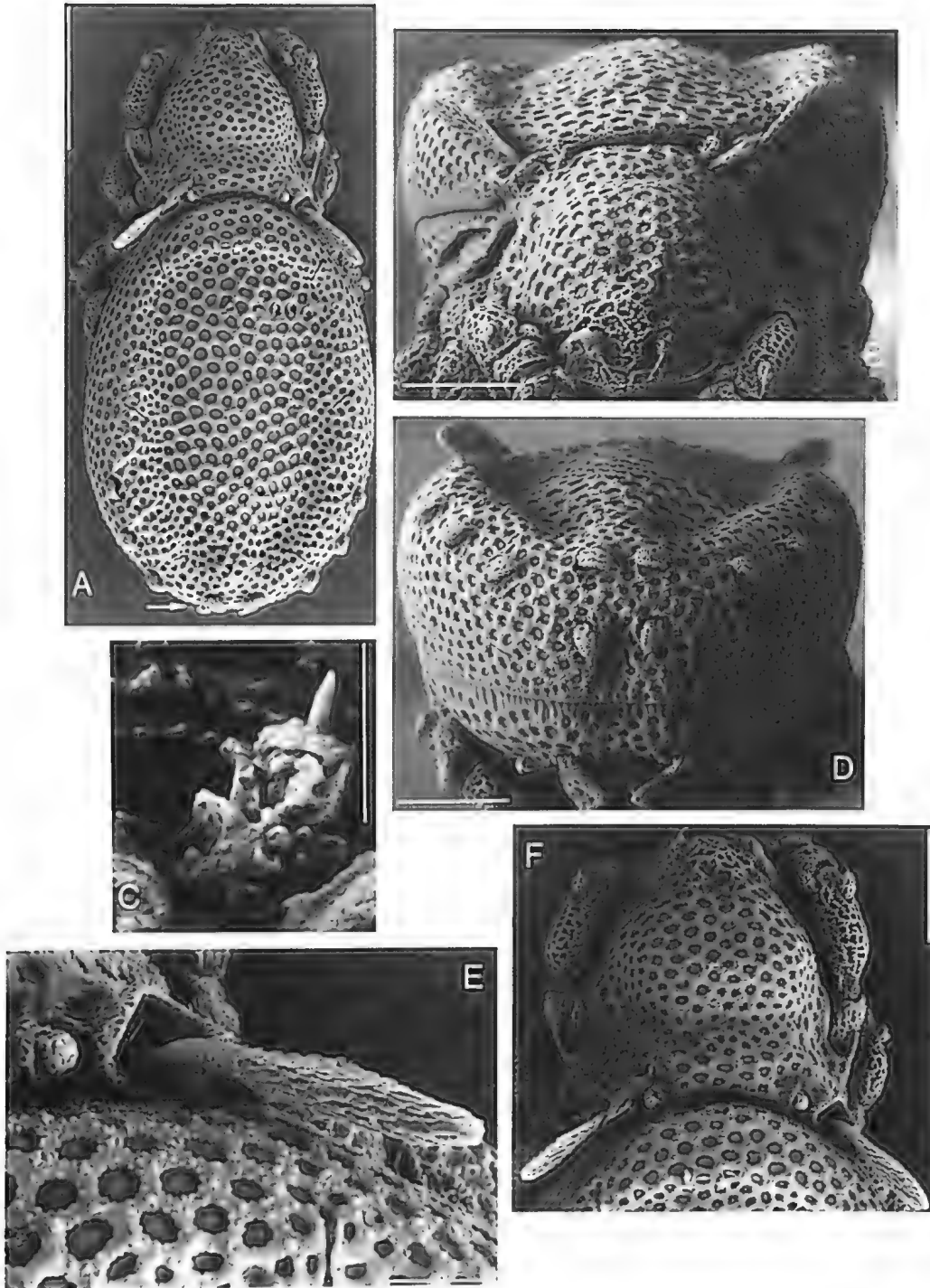


Fig. 31. *Pedrocortesella leei* n.sp. A, body, dorsal, arrows right to left label setae *h1*, *p1*, *lp*, *p2*, *p3*; B, body, frontal; C, interlamellar seta *in*; D, body, posterior; E, bothridium, sensillum and seta *in*, dorsal; F, prodorsum, dorsal. Scale bars: A = 100  $\mu$ m; B,D,F = 50  $\mu$ m; E = 20  $\mu$ m; C = 10  $\mu$ m.

### *Pedrocortesella leei* n.sp.

Figs 1D, 31–33

**Type material.** New South Wales: HOLOTYPE adult, AM KS43690 Mount Allyn, near Barrington Tops, via Salisbury, 32°08'S 151°26'E berlese extraction bark scraped from *Nothofagus moorei*, temperate rainforest, G.S.Hunt, 20 September 1993. PARATYPE adults. ANIC, same data as holotype, 1 adult; SAMA, same data, 1 adult; AM KS46553 SEM stub. no 337 (ill.), same data, 3 adults.

**Diagnosis.** Body small-medium, length about 400–450  $\mu$ m; scalps rarely (if at all) carried by adult; prodorsum

without carinae; sensillum a flattened tuberculate blade though length less than interbothridial distance; notogaster foveate; 5 pairs notogastral setae, with cerotegument they are leaf-shaped; genitoanal chaetotaxy 6:1:2:2, genital setae essentially in straight file, both pairs adanal setae near posterior margin of anal valve; claw stalk very short.

### Description

**ADULT:** *Body:* brown; length 410  $\mu$ m, 420  $\mu$ m. *Cerotegument:* body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster with numerous cushion-like grains of cerotegument (Fig.

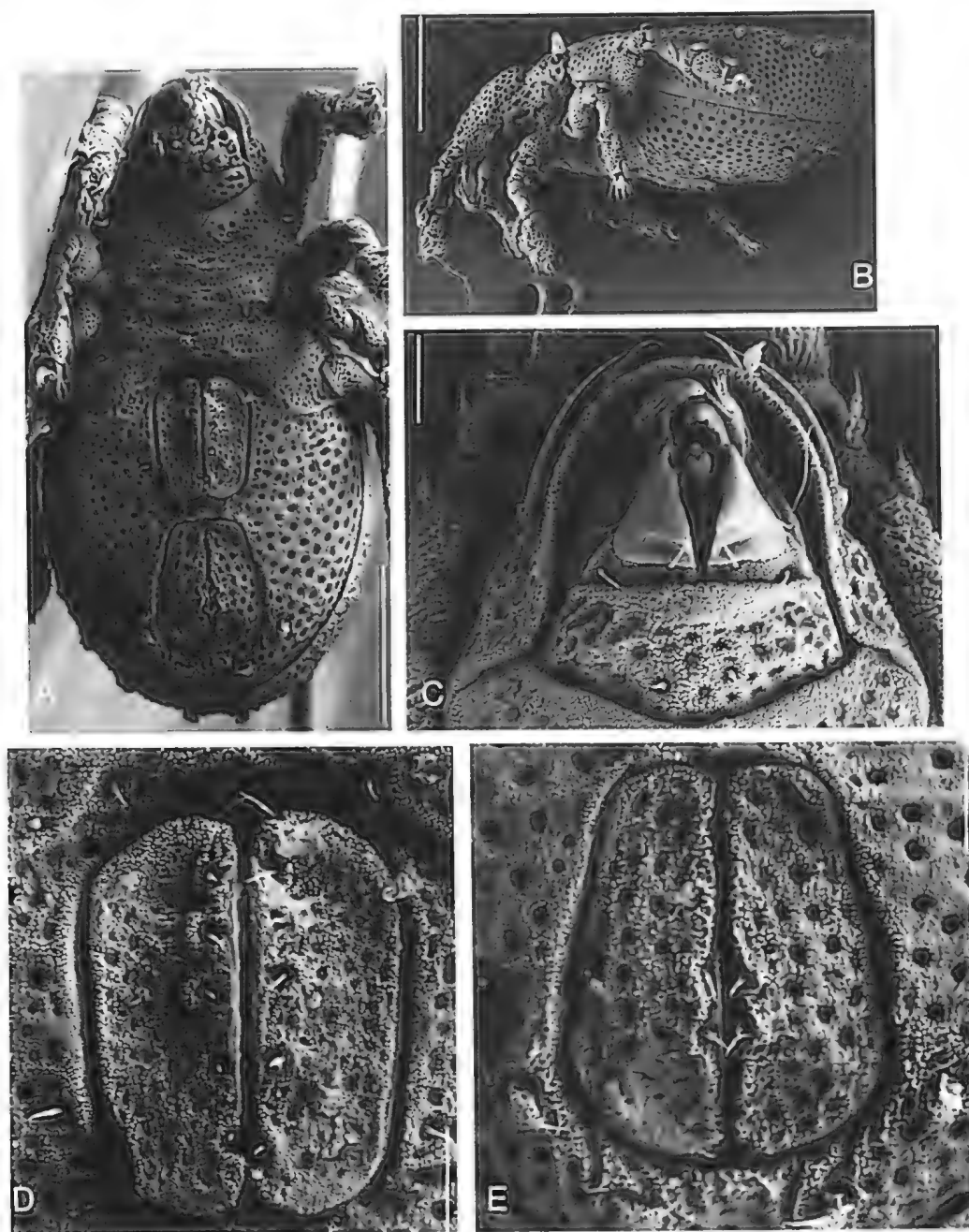


Fig. 32. *Pedrocortesella leei* n.sp. A, body, ventral; B, body, lateral; C, subcapitulum; D, genital valves; E, anal valves. Scale bars: A,B = 100  $\mu$ m; C-E = 20  $\mu$ m.

31E). Setae *ro* and *le* and notogastral setae with cerotegument at their bases; notogastral setae with thick lateral fringes of cerotegument giving the seta a tapering leaf-like appearance. *Prodorsum*: integument more or less uniformly reticulate-foveate including area between bothridia; foveae without visible pores; carina between *le* and *ro* absent; *le* dorsolateral and situated close to anterior of rostrum, distance between them about 0.5 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal tooth strongly curved anteriad, tapering abruptly near its base into a long delicate spine. Bothridium abutting notogaster but not closely adpressed (Fig. 31E), wall diamond-shaped, posterolateral carina weak, away from notogaster; sensillus length about 0.8 interbothridial distance, with long flattened tuberculate blade (Fig. 31B), posterior margin of prodorsum forming

a smooth arc between bothridia; area between bothridia and elsewhere on prodorsum smoothly contoured (Fig. 31F), without carinae; *in* small, its supporting apophysis abutting bothridial base; at edge of dorsosejugal furrow, spiniform, base encased in cerotegument (Fig. 31C,E). *Exuvial scalps*: none seen. *Notogaster*: oval, length:width 290:210. Intramarginal depression oval but narrower posteriorly. Notogaster strongly foveate-reticulate, not perforated by pores; foveae with slightly raised central area (Fig. 31E); posterior margin not invaginate when viewed from above, without carina between setae *pl* when viewed posteriorly (Fig. 31D). Fissura *ia*, *im* and *ip* oblique to sagittal plane; 5 pairs of short notogastral setae, with broad tapering fringe of cerotegument, arising from pits; *hl* close to each other and directed mesad, each located at posterior margin; *pl* inserted

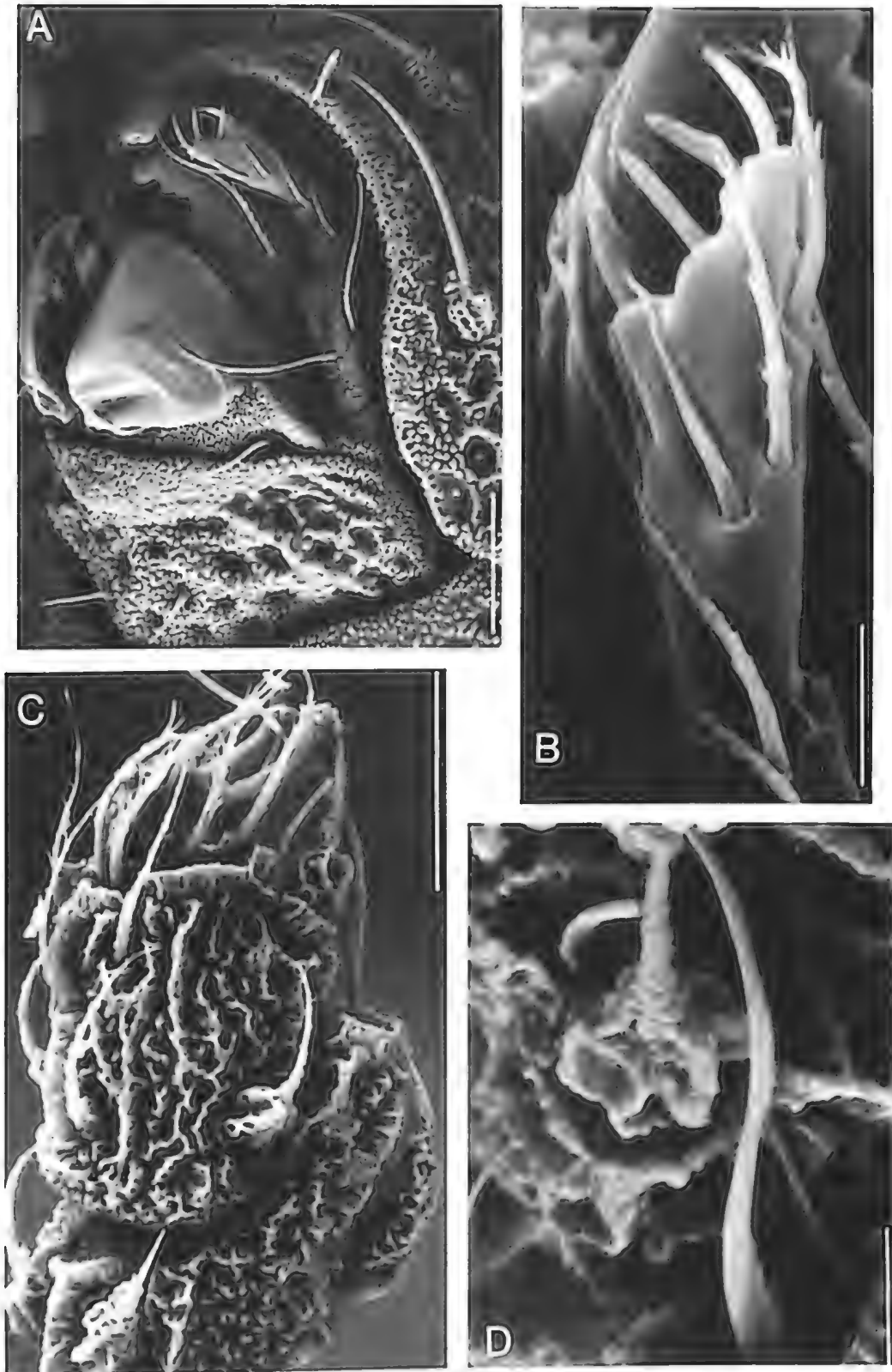


Fig. 33. *Pedrocortesella leei* n.sp. A, subcapitulum, ventrolateral; B, pedipalp tarsus, antiaxial; C, leg I tibia (distal) and tarsus, antiaxial; D, leg I tarsal cluster, distodorsal. Scale bars: A,C = 20  $\mu$ m; B,D = 5  $\mu$ m.

mid-height on posterior flank, similarly spaced to *hl*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise along posterolateral flank, their insertions visible from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted just posterior to it (Fig. 31A). *Gnathosoma*: rutella basally with moderate concave flexure and moderate lateral buttressing, pointed mesad processes and transverse striations absent (Figs 32C, 33A); Pedipalp

tarsus with setae (*vt*) with short side branches, *cm* branches very short; *l''* smooth; apophysis supporting seta *acm* low; solenidion *omega* reaching to base of *acm* (Fig. 33B). *Epimeral region*: weakly convex anterior to genital valves, not tending to overhang them. *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture



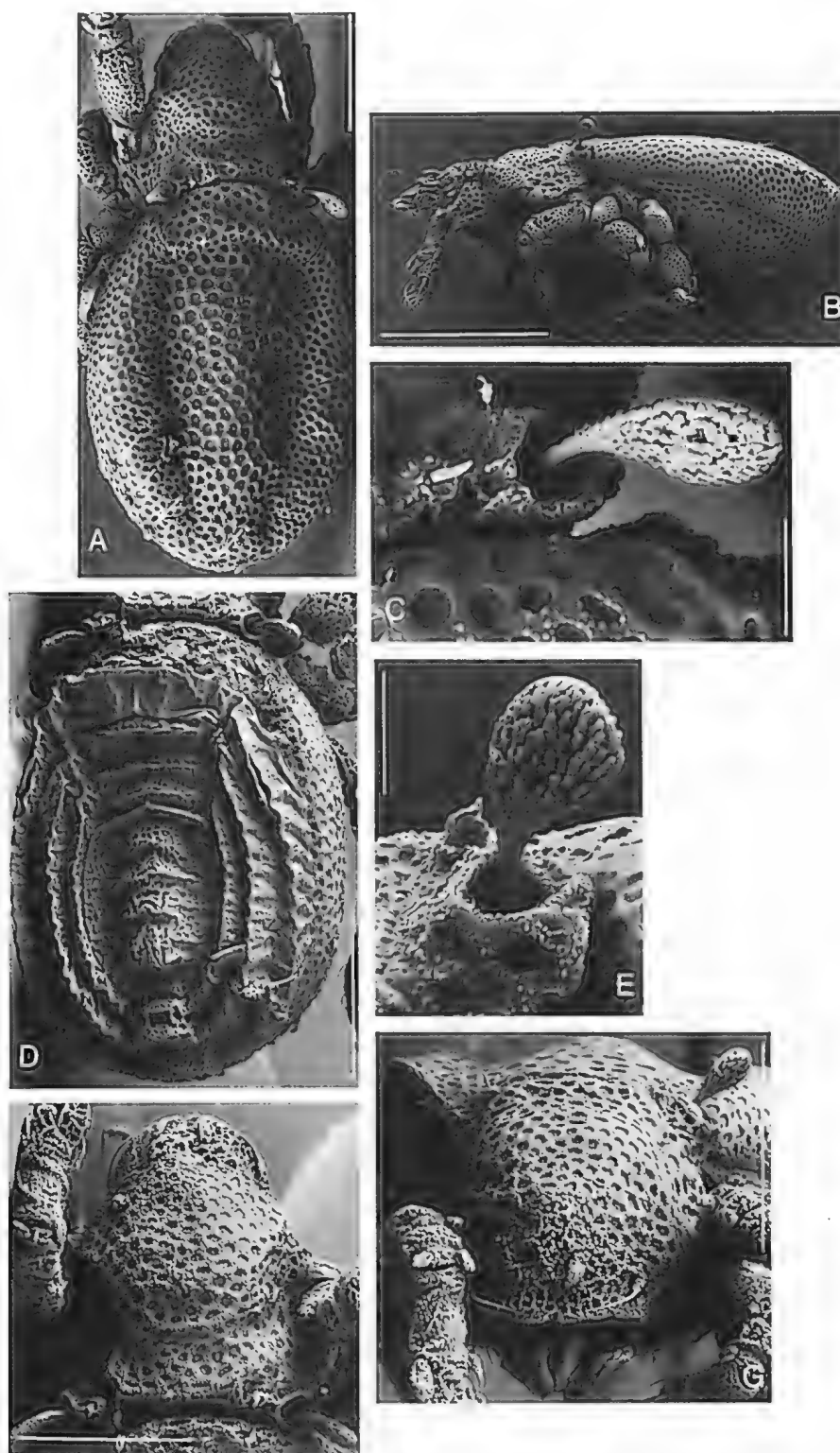


Fig. 34. *Pedrocortesella nortoni* n.sp. A, body, dorsal (scalps removed); B, body, lateral; C,E, bothridium, sensillus and seta *in*, dorsal and lateral; D, exuvial scalps, dorsal; F,G, prodorsum, dorsal and frontal. Scale bars: A,B,D,F,G = 100  $\mu$ m; C,E = 20  $\mu$ m.

but there is a wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 32A). Ventral plate reticulate-foveate. Genitoanal chaetotaxy 6:1:2:2; genital setae essentially in straight file but with *g5* placed  $>0.5$  valve length; *g1* inserted at anterior margin of valve close to its inner corner; *g6* inserted well anterior to inner posterior corner, in marginal notch; setae *ag* inserted at level between *g5* and *g6*; setae *ad1* distinctly postanal, *ad3* presumably not present.

*Legs.* Distal apophysis of tibia overlaps more than 50% of tarsus (Fig. 33C), partly due to extreme terminal compression of the tarsus. Tarsal cluster of leg I placed distodorsally on apophysis, *fi''*, *omega 1* and 2 enclosed in common rim, no partition separating *fi''* from *omega 1* and 2, latter close together, *fi''* with heavy cerotegument at base (Fig. 33D); tarsus without distal recess for receiving retracted unguitractor complex, stalk very short.

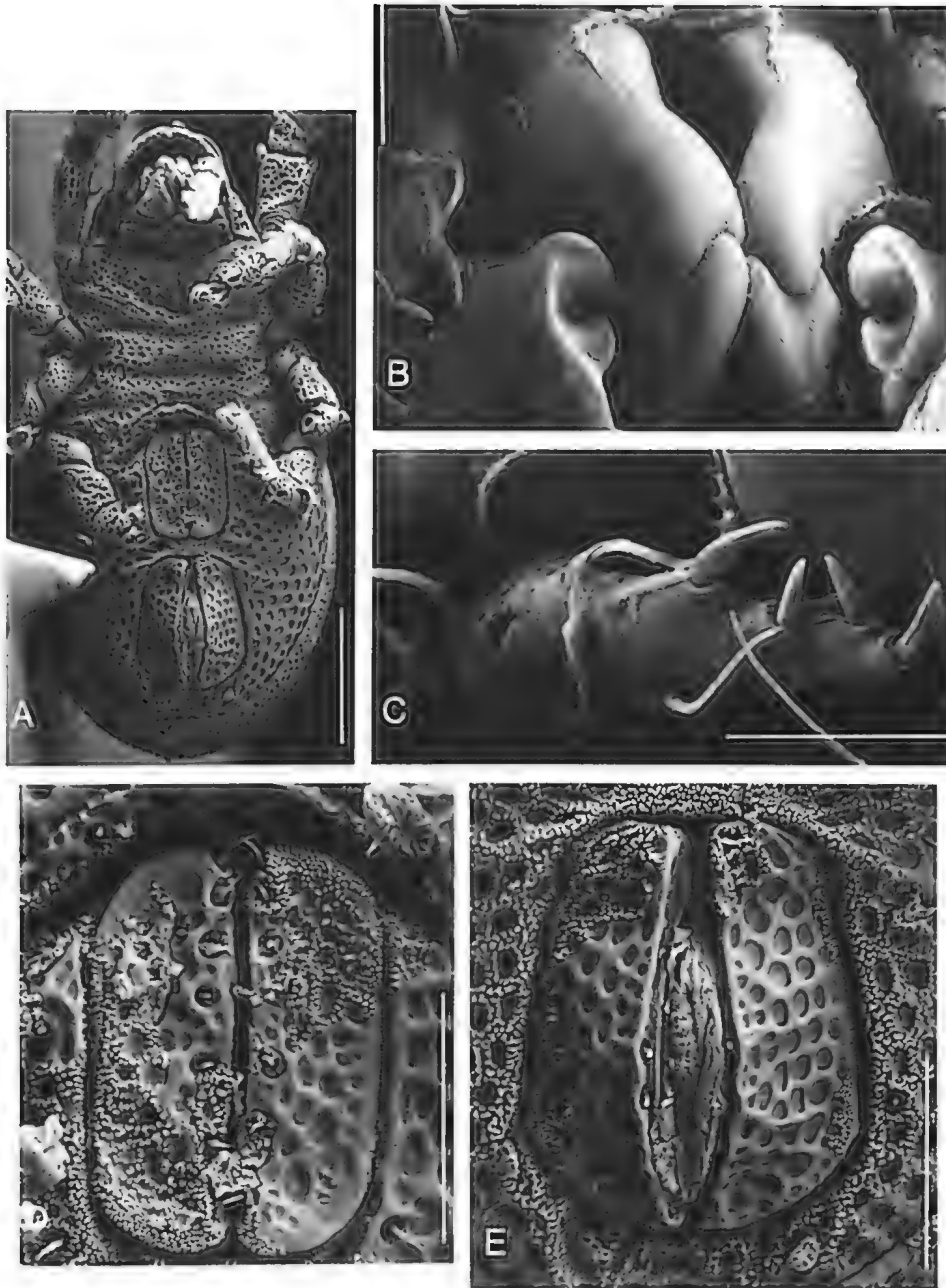


Fig. 35. *Pedrocortesella nortoni* n.sp. A, body, ventral; B, chelicerae and distal part of rutella; C, pedipalp tarsus, dorso-antiaxial; D, genital valves; E, anal valves. Scale bars: A = 100  $\mu$ m; D–E = 50  $\mu$ m; B,C = 10  $\mu$ m.

**Comments.** In this species, the presence of a smoothly contoured prodorsum, two pairs of adanal setae and a smooth seta *l*'' on the pedipalp tarsus is very unusual for *Pedrocortesella*. The species is close to *P. nortoni* but differs from this species in having a longer sensillus, six pairs of genital setae, and in lacking a mental tectum.

**Distribution.** Known only from the type locality in the Barrington Tops area, central eastern New South Wales.

#### *Pedrocortesella nortoni* n.sp.

Figs 34–36

**Type material.** Tasmania: HOLOTYPE adult. ANIC, Cradle Mountain Camping Ground, 41°35'S 145°55'E, 880 m, Pyrethrum knockdown from trees, H. Mitchell, 15 November 1989. PARATYPE adults. AM KS43746, same data as holotype,

1 adult. AM KS46569 SEM stub no. 274 (ill.), Cradle Mountain Camping Ground, 41°35'S 145°55'E, pyrethrum knockdown from trees, R. Coy, 17 November 1989, 1 adult; AM KS46570 SEM stub no. 275 (ill.), same data, 1 adult.

**Diagnosis.** Body medium, length about 450–500  $\mu$ m; scalps loosely carried by adult and may be missing; sensillus terminates in rounded club not flattened blade; notogaster foveate, 5 pairs notogastral setae, with cerotegument they are leaf-shaped; mental tectum present; genitoanal chaetotaxy 7:1:2:2; both adanal setae near posterior margin of anal valve; claw stalk very short.

#### Description

**ADULT: Body:** brown; length 470  $\mu$ m, 480  $\mu$ m. **Cerotegument:** body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster

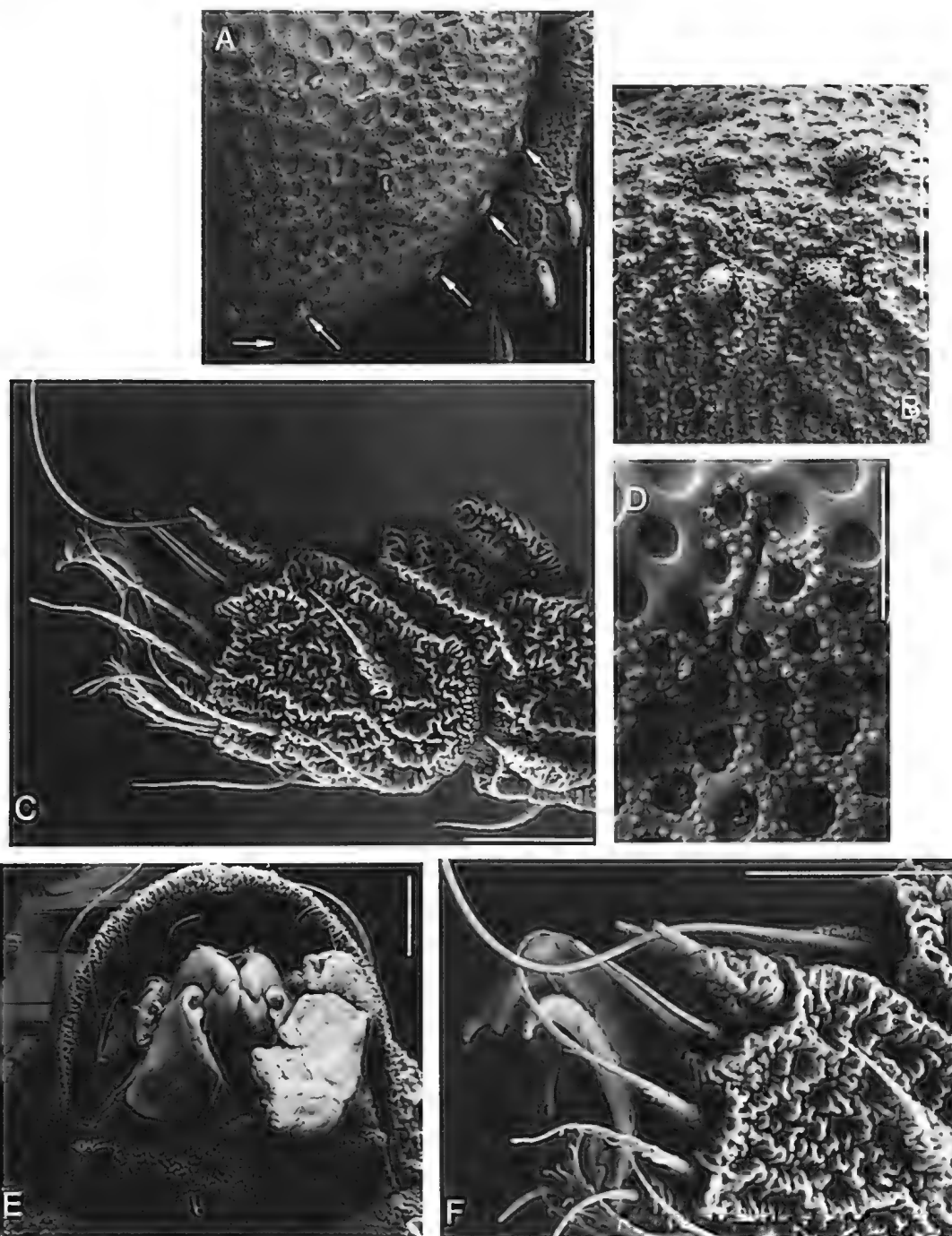


Fig. 36. *Pedrocortesella nortoni* n.sp. A, part of posterior of notogaster, dorsal; B, setae *h1* and *p1*, posterior view; C, leg I tibia (distal) and tarsus, antiaxial; D, ornamentation of notogaster and fissura *im*, lateral at top of SEM. E, Subcapitulum; F, leg I, distal view. Scale bars: A,B = 50  $\mu$ m; C,D,F = 20  $\mu$ m.

with numerous cushion-like grains of cerotegument (Fig. 36D). Setae *le* and notogastral setae with thick lateral fringes of cerotegument giving the seta a tapering appearance (Fig. 34G); *ro* with cerotegument at its base. *Prodorsum*: integument more or less uniformly reticulate-foveate including area between bothridia; foveae without visible pores; carina between *le* and *ro* absent; *le* dorsolateral and situated close to anterior of rostrum, distance between them about 0.4 distance between *ro*, *ro* ventrolateral, insertion just visible from above. Pedotectal tooth strongly curved anteriad, tapering abruptly near its base into a long spine. Bothridium abutting notogaster but not closely adpressed (Fig. 34F), wall oval; posterolateral carina moderate, close to

notogaster; sensillus length about 0.3 interbothridial distance, and rounded, densely tuberculate (Fig. 34E); posterior margin of prodorsum forming a smooth arc between bothridia; *in* small, its supporting apophysis abutting bothridial base; just inside edge of dorsosejugal furrow, spiniform, base encased in cerotegument (Fig. 34C,E). *Exuvial scalps*: loosely carried or lost; anterior margins of scalps not tightly compressed against neighbouring ones. *Notogaster*: oval, length:width without scalps 340:250. Intramarginal depression similar in shape to *P. propinqua*. Notogaster strongly foveate-reticulate, not perforated by pores (Fig. 36D); posterior margin not invaginate when viewed from above, without carina between setae *p1* when viewed posteriorly (Fig.

36B). Fissura *ia* and *im* oblique to sagittal plane, *ip* subperpendicular; 5 pairs of short notogastral setae (Fig. 36A), with thick cerotegument coating, arising from small pits; *hl* moderately separated, each located at posterior margin; *p1* inserted about mid-height on posterior flank, slightly closer together than *hl*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise along posterolateral flank, their insertions seen from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted just posterior to it (Figs 34A, 36A). *Gnathosoma*: rutella basally with weak concave flexure and moderate lateral buttressing, weak transverse striations present (Fig. 36E). Pedipalp tarsus with setae (*vt*) with short side branches, *cm* branches very short; *l''* smooth; apophysis supporting seta *acm* weak, <0.5 seta length; solenidium *omega* reaching to base of *acm* (Fig. 35C). *Epimeral region*: weakly convex anterior to genital valves, not tending to overhang them. Epimeral chaetotaxy 3,1,3,3. *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 35A). Ventral plate reticulate-foveate. Genitoanal chaetotaxy 7,1,2,2; genital setae essentially in straight file (Fig. 35D); *g1* inserted at anterior corner of valve in marginal notch; *g7* inserted well anterior to inner posterior corner, in marginal notch; setae *ag* inserted at level posterior to *g7*; setae *ad1* distinctly postanal, *ad3* presumably not present. *Legs*. Apophysis of tibia I overrides about 0.5 of tarsus (Fig. 36C). Tarsal cluster of leg I placed distodorsally on apophysis, *ft''*, *omega 1* and *2* enclosed in common rim (Fig. 36F), no partition separating *ft''* from *omega 1* and *2*, latter close together, *ft''* with heavy cerotegument at base; opening of cavity containing undeveloped seta *epsilon* not seen; tarsus without distal recess for receiving retracted unguinal complex, stalk very short.

**Comments.** This species resembles *P. leei* in having two pairs of adanal setae but differs in having seven pairs of genital setae, an ovoid, clavate sensillus, and a weakly developed mental tectum. It resembles *P. enigma* in having a clavate sensillus and transverse striations on the rutella but differs in only having two pairs of adanal setae and two pairs of anal setae.

**Etymology.** This species is named for Professor Roy Norton's in recognition of his contribution to acarology, and the encouragement he has given me.

**Distribution.** Known only from the type locality, north-western Tasmania.

### *Pedrocortesella obesa* n.sp.

Figs 10F–H, 37, 38

**Type material.** Western Australia: HOLOTYPE adult, WAM, SEM stub no. S/421 (ill.), 4.75 km E.S.E. of Margaret River, 33°57'52"S, 115°27'22"E, Marri forest with *Agonis flexuosa*, berlesate leaf litter, M. Peterson, 8–14 February 1992. PARATYPE adult, WAM, SEM stub no. S/157 (ill.), same data as holotype, 1 adult.

**Diagnosis.** Body small-medium, length about 400–450 µm; scalps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster punctate,

with caudal notch when viewed from above, 5 pairs of notogastral setae, epimera III–IV strongly convex anterior to valves and tending to overhang them; genital and anal vestibules close; genitoanal chaetotaxy 7:1:2:3; genital setae in essentially straight file, level of insertion of *ad3* adjacent to posterior half of anal valve; claw stalk short.

### Description

**ADULT: Body:** brown; length of type specimens 430 µm, 440 µm. **Cerotegument:** body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster and rim of bothridium highlighted with cushion-like tubercles of cerotegument which may coalesce into crests (Fig. 37D,F). Setae *ro* and *le* with layer of cerotegument giving a granular appearance; notogastral setae without obvious cerotegument. Legs with cerotegument capping the reticulate surface ornamentation which is of much lower relief than in *P. propinqua*. **Prodorsum:** integument divided into 3 fields: rostral field with reticulations; anterior to median transverse groove a somewhat irregular field perforated by pores and with a strong transverse carina; a bothridial field with pores on carinae (Fig. 37B). *le* dorsolateral, distance between them about 0.6 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal tooth similar to *P. propinqua*. Bothridium abutting but not closely adpressed to notogaster (Fig. 37D), wall somewhat diamond shaped, posterolateral carina weak, situated away from notogaster; sensillus length subequal to interbothridial distance, with long flattened tuberculate blade. *in* small, set about 0.5 bothridial diameter from bothridium at edge of dorsosejugal furrow, spiniform but largely encased in cerotegument (Fig. 37D). **Exuvial scalps:** none seen. **Notogaster:** oval, length:width holotype 320:250. Intramarginal depression U-shaped, interrupted anteriorly by a raised area continuous with central plateau. Notogaster punctate, punctations tending to be arranged in lines more laterally (Fig. 37A,F); posterior margin slightly invaginate when viewed from above, without a mesal carina when viewed posteriorly (Fig. 37G). Fissura *ia* subparallel *im* subparallel-oblique and *ip* perpendicular to sagittal plane. 5 pairs of notogastral setae; *hl* widely separated, each located inside posterior margin; *p1* inserted midheight on posterior flank, similar distance apart to *hl*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise just inside posterolateral flank, their insertions visible from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted posterior to it (Fig. 37E). *Gnathosoma*: rutella basally with strong concave flexure and lateral buttressing, without pointed mesad process, transverse striations absent (Fig. 38C). Pedipalp not examined. **Epimeral region:** epimera IV very strongly convex immediately anterior and lateral to genital valves, tending to overhang them. **Genitoanal region:** separation of anal and genital vestibules relatively narrow with deep transverse grooves and a narrow isthmus between the vestibules (Fig. 38A,E). Punctate. Genitoanal chaetotaxy 7:1:2:3; genital setae essentially in straight file, *g1* subequal to other setae, inserted posterior to inner anterior corner, not in marginal notch; *g5* situated at about 0.5 valve length, *g7* inserted anterior to inner posterior corner, not in marginal notch; setae *ag* inserted at level posterior to *g6*; setae *ad1* distinctly postanal, more so than *P. propinqua*, *ad3* level in



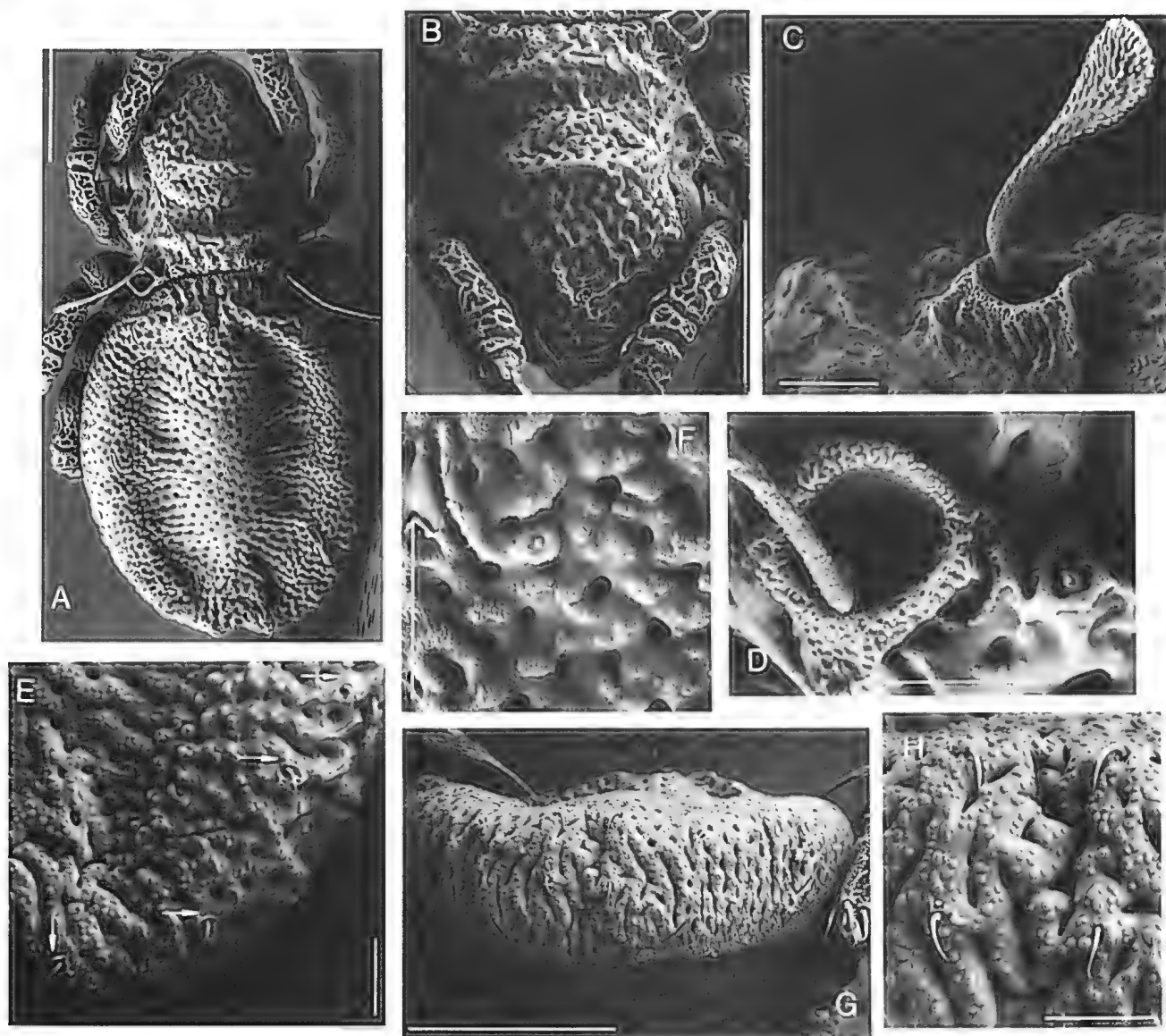


Fig. 37. *Pedrocortesella obesa* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, bothridium, sensillus and seta *in*, lateral; D, bothridium and seta *in*, dorsal; E, notogaster, posterior, right side, dorsal, arrows left to right label setae *h1*, *lp3*, *p2*, *p3*; F, notogastral integument and fissura *im*; G, notogaster, posterior view; H, notogastral setae *h1* and *p1*, posterior view. Scale bars: A,B,E,G = 100  $\mu$ m; C,D,F,H = 20  $\mu$ m.

posterior half of anal valve. *Legs*. Distal apophysis of tibia overlaps about 50% of tarsus (Fig. 10F). Tarsal cluster of leg I placed distodorsally on apophysis, above and slightly proximal to setae *tc*; *ft* enclosed in its own rim (Fig. 10H); *omega 1* and 2 within a separate rim, widely separated, hole (presumably cavity for undeveloped *famulus*) present ventral to solenidia (Fig. 10H, arrow); tarsus lacking distal recess for receiving retracted unguinal complex, stalk short.

**Etymology.** The specific epithet alludes to the prominent bulge which tends to overhang the genital area.

**Distribution.** Known only from the type locality, southwestern Western Australia.

### *Pedrocortesella propinqua* P. Balogh

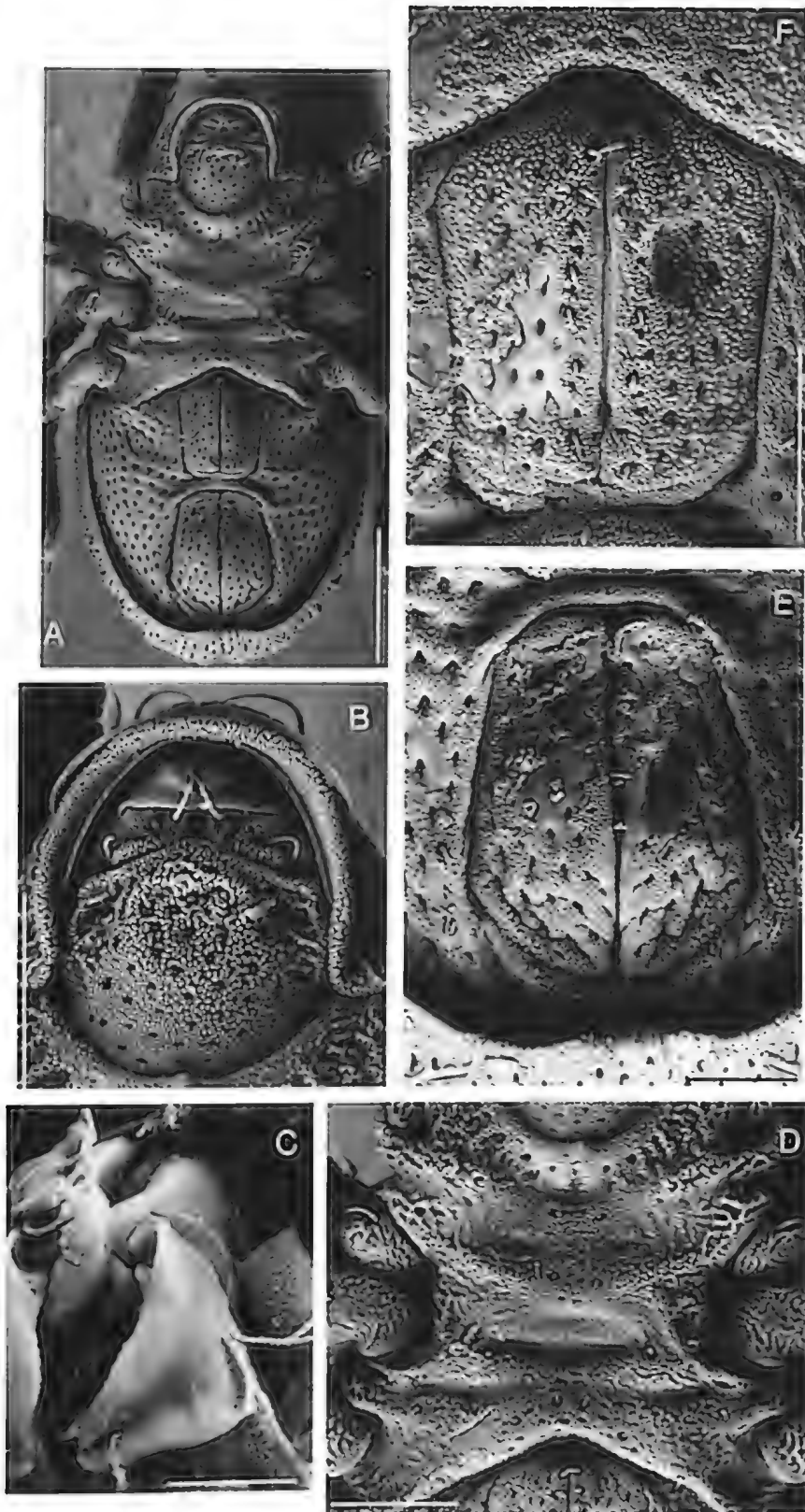
Figs 10A–C,I, 39, 40

*Pedrocortesella propinqua* P. Balogh, 1985: 51, fig. 2A–D.

*Pheroliodes propinqua*.—Woas, 1992: 144.

**Type material.** New South Wales: HOLOTYPE adult, ANIC, Barrington Tops, near Salisbury, *Nothofagus moorei* leaf litter, temperate rainforest, 1520 m, G.B. Monteith, 10 February 1965.

**Material examined.** New South Wales: AM KS46510, SEM stub no. S/295, Allyn River Park near crossing of Allyn River, N. of Salisbury, 32°10'S 151°30'E, subtropical rainforest, berlesate bark scraped from trees, G.S. Hunt, 5 October 1993, 1 adult; AM KS43669 Mount Allyn, near Barrington Tops, 32°08'S 151°26'E bark scraped from *Nothofagus*, temperate rainforest, G.S. Hunt, 20 Sept. 1993, 13 adults; AM KS46518, SEM stub no. S/333 (ill.), same data, 3 adults; AM KS46511, SEM stub no. S/132, 15 km S. Kempsey beside Pacific



**Fig. 38.** *Pedrocortesella obesa* n.sp. A, body, ventral; B, subcapitulum; C, rutellum, ventral; D, epimeral region; E, anal valves; F, genital valves. Scale bars: A = 100 µm; B,D,F = 50 µm; C,E = 20 µm.

Highway, 32°12'S 151°49'E, dry sclerophyll, berlesate leaf and bark litter from base of *Eucalyptus*, G.S.Hunt, 18 July 1992, 1 adult; AM KS43665, S. of Grafton beside Pacific Highway, 30°00'S 153°06'E, dry sclerophyll, berlesate leaf and bark litter, G.S.Hunt, 18 July 1992, 1 adult; AM KS46512, SEM stub no. S/145, same data, 3 adults; AM KS46513, SEM stub no. S/151-05 (ill.), S. of Casino beside Casino-Grafton road, 29°06'S 153°00'E, dry sclerophyll, berlesate leaf and bark

litter, G.S.Hunt, 18 July 1992, 1 adult; AM KS43668, same data, 1 adult; AM KS46514, SEM stub no. S/239, Echo Head Falls, Kanangra-Boyd National Park, 33°59'S 150°06'E, ANIC berlesate 856, litter near creek, L.Hill, 3 October 1982, 1 adult; AM KS46515 SEM stub no. S/249, same data, 1 adult; ANIC, same data, 1 adult; AM KS46516, SEM stub no. S/246 (ill.), 9.6 km S. Gilgandra, 31°49'S 148°39'E, ANIC berlesate 89, L.A.Mound, 6 June 1968, 2 adults; AM KS43667

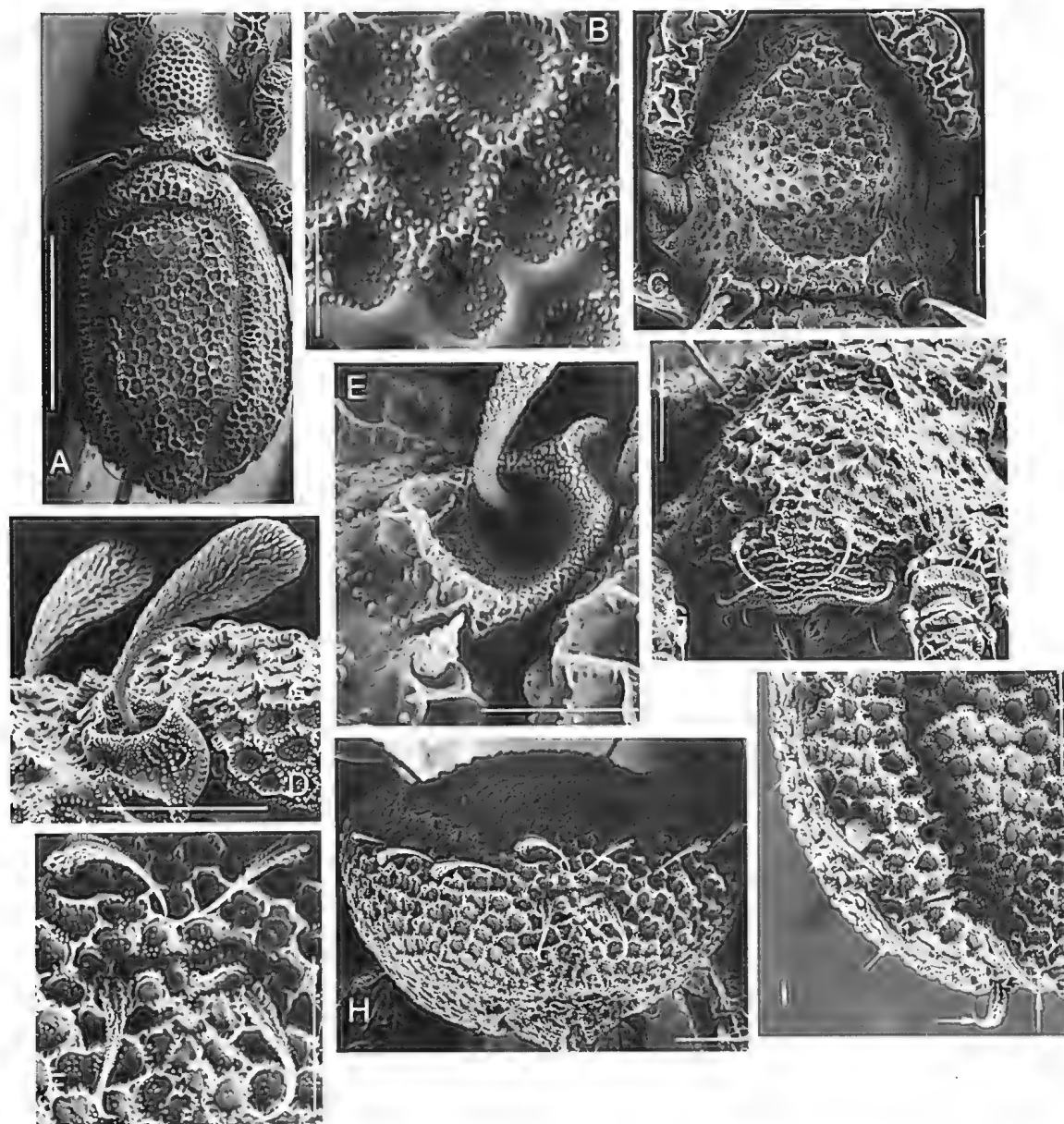


Fig. 39. *Pedrocortesella propinqua* P. Balogh. A, body, dorsal; B, notogastral integument; C, prodorsum, dorsal; D, bothridium, sensillus and seta *in*, lateral; E, bothridium and seta *in*, dorsal; F, caudal region of notogaster, setae *hl* and *pl*; G, prodorsum, frontal; H, notogaster, posterior; I, notogaster, posterior, dorsal, arrows right to left label setae *hl*, *pl*, *lp*, *p2*, *p3*. Scale bars: A = 200  $\mu$ m; C,D,F–I = 50  $\mu$ m; B,E = 20  $\mu$ m. A,C,E = Mount Allyn; B = Harley Vale; D,F–I = Casino.

same data, 3 adults; ANIC, same data, 6 adults; AM KS46517, SEM stub no. S/002 (ill.), Gulpa Island State Forest, Deniliquin, 35°43'S 145°00'E, River Red Gum flood plain, berlesate grass and soil, G.S.Hunt, July 1991, 1 adult; AM KS43668, same data but from base of tree in dry plot, 8 adults; AM KS46519, SEM stub no. S/338 (ill.), Hartley Vale Beck, 33°32'S 150°14'E, leaf litter at foot of eucalypt in old cemetery, berlesate, G.S. Hunt, Easter 1992, 1 adult; AM KS43670, Tilbuster Hill, N. of Armidale, beside the New England Highway, 30°19'S 151°42'E, leaf litter, G.S. Hunt, 11 June 1995, 1 adult; ANIC, 13 km S. of Collarenebri, 29°34'S 148°35'E, berlese extraction *Geijera* leaf litter, ANIC berlesate 88, L.A. Mound, 5 June 1968, 35 adults plus nymphs; AM KS46520 SEM stub no. S/432, same data, 1 adult; AM KS46521, SEM stub no. S/431, Liverpool Ranges, New England Highway near Murrurundi, 31°45'S 150°48'E, leaf litter, G.S. Hunt, 11 June 1995, 1 adult.

Queensland: AM KS46522, SEM stub no. S/269, Bulburin State Forest, via Builyan, 24°34'S 151°29'E, dry sclerophyll, berlesate bark scraped from trunks and litter, G.S.Hunt, 6 July 1993 3 adults; QM, same data, 1 adult.

South Australia: AM KS46523, SEM stub no. S/208, 4.8 km W. Parilla, 35°18'S 140°39'E, Mallee, ANIC berlesate 184, R.W. Taylor, 12 January 1970, 3 adults.

**Diagnosis.** Body medium sized, length about 500–550  $\mu$ m; scalps rarely (if at all) carried by adult; sensillus with long flattened blade; bothridium diamond-shaped; notogaster entirely foveate-reticulate, many foveae with pore; 5 pairs of long notogastral setae, notogaster without caudal notch when viewed from above; broad separation of genital and anal vestibules; genitoanal chaetotaxy 7:1:2:3, genital setae in arcuate file, level of



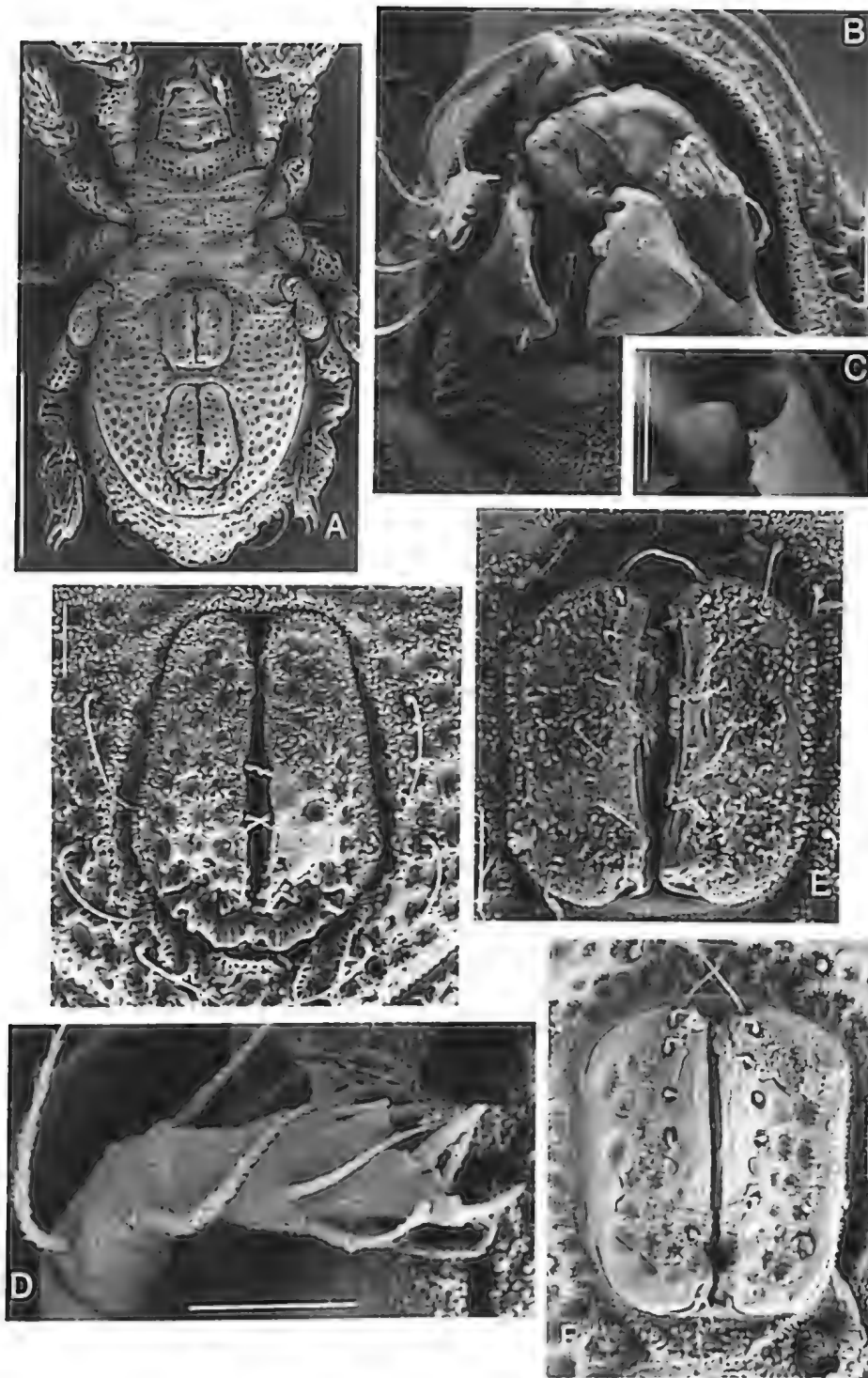


Fig. 40. *Pedrocortesella propinqua* P. Balogh. A, body, ventral; B, subcapitulum; C, detail of chelicera; D, pedipalp tibia and tarsus; E, genital valves; F, genital valves without some cerotegument; G, anal valves. Scale bars: A = 200  $\mu$ m; B,E–G = 25  $\mu$ m; C,D = 10  $\mu$ m. A,D,E,G = Mount Allyn; B = Casino; C = Gilgandra.

insertion of *ad3* adjacent to proximal 30–40% of anal valve; claw stalk short.

### Redescription

**ADULT:** *Body:* brown; length ( $\mu$ m) of 6 eastern coast specimens 520, 530, 530, 540, 550, 550 (mean 537). *Cerotegument:* crests of reticulations on prodorsum and notogaster and rim of bothridium with stellate tubercles of cerotegument which may coalesce giving a “stitched” appearance (Fig. 39B) or “buttressed-wall” appearance

(Fig. 39I,D,F); foveae with scattered granules of cerotegument (Fig. 39B). Setae *ro* and *le* and notogastral setae usually with heavy, tapering ribbed encrustation of cerotegument along most their length (Fig. 39F–I). Legs with strong buttressed walls of cerotegument forming an intricate, irregular “honey-comb” of high relief on all segments. *Prodorsum:* integument divided into 3 fields: anterior rostral field patterned by relatively loose polygonal reticulations; a larger middle field anterior to median transverse furrow with closely spaced, deep foveae each perforated by a pore and separated from

each other by polygonal reticulations of high relief; a bothridial field of more complex topography with carinae and reticulations. *le* dorsolateral, distance between them about 0.66 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal tooth gradually curving to blunt point. Bothridium closely abutting notogaster but wall not deeply excavated posteriorly (Fig. 39E), more or less diamond shaped with angles directed anterad, posterad, mesad and laterad; strong posterolateral carina arising from laterad angle removed from notogaster; sensillus length subequal to interbothridial distance, with long flattened tuberculate blade, broadest subdistally and rounded at end (Fig. 39D). Setae *in* small, set close to mesad angle of bothridium just inside edge of dorsosejugal furrow (Fig. 39E), spiniform but largely encased in cerotegument (Fig. 40E). *Exuvial scalps*: none seen. *Notogaster*: oval, length:width 370:260, 370:260, 390:310, 390:300, 410:310, 425:325. Intramarginal depression suboval or "vase-shaped", broadest and somewhat angular anteriorly, interrupted posteriorly; with steep external margin, internally sloping more gradually to central plateau. Dorsum entirely foveate-reticulate, many foveae with small eccentric pore (Fig. 39B). Posterior margin not invaginate when viewed from above, with slight mesal furrow and no prominent carina (though reticulations may become linear) ventral to setae *p1* when viewed posteriorly. Fissura *ia* subparallel and *im* and *ip* oblique-subperpendicular to sagittal plane. 5 pairs of long notogastral setae; *h1* widely separated but converging at their tips, each located well inside posterior margin at posterior end of intramarginal depression; *p1* inserted high on posterior flank, closer together than *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise at or just inside posterolateral margin, their insertions seen from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted lateral to it (Fig. 39I). *Gnathosoma*: pedipalp tarsus with setae (*vt*) with short barbs, *cm* and *l'* barbs very short; apophysis supporting seta *acm* low; solenidion *omega* reaching to base of *acm*. Rutella basally with moderate concave flexure and buttressing, but without pointed mesad process; transverse striations absent (Fig. 40B). *Epimeral region*: with depressed area immediately anterior to genital valves. *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 40A). Aggenital and adanal areas reticulate-foveate, some foveae with pores; genital and anal valves with smaller foveae of similar depth on both valves, no pores; posterior margin of anal valves often crenellate. Genitoanal chaetotaxy 7:1:2:3; genital setae in arcuate file, all except *g7* removed from mesal suture, *g5* most so; *g1* long and overlapping, inserted in a notch on anterior margin slightly removed from inner anterior corner of valve; *g5* situated at about 0.5 valve length, *g6* usually closer to *g7* than to *g5*, *g7* inserted in notch in inner posterior corner; setae *ag* inserted at level between *g6* and *g7*; setae *ad1* immediately postanal, *ad2* at or just posterior to posterolateral corner of anal valve, level of insertion of seta *ad3* adjacent to proximal 30–40% of anal valve; *ad3* subequal to *ad2* in distance from valve. *Legs*. Distal apophysis of tibia overlaps about 50% of tarsus. Tarsal cluster of leg I placed distodorsally on a short apophysis, above and slightly proximal to setae

*tc*; *ft''*, *omega 1* and 2 enclosed in same major rim, *omega 1* and 2 widely separated and shorter than *ft''*, hole (presumably cavity containing undeveloped *famulus*) visible (arrow, Fig. 10C), *ft''* longer than solenidia; tarsus lacking distal recess for receiving retracted ungual complex, stalk medium length.

**Variation.** The number of notogastral foveae perforated by a pore is variable. There are very few in the Mount Allyn population, whereas a pore is present in almost every fovea in the Gulpa Island population. Seta *in* is more vestigial in the Gilgandra and Gulpa Island populations (riverine plains of western New South Wales) and tends to lack a supporting apophysis (Fig. 10I). Aggenital and adanal setae are very long in the Mount Allyn population (Fig. 40G), and relatively short in Gulpa Island population. Side barbs on non-eupathidic setae of the pedipalp tarsus are longer in the Gulpa Island population.

**Comments.** This species is quite variable, both in its morphology and habitat requirements, even within its eastern coastal range. Further material and research may reveal that more than one species exists. For example, the Gulpa Island and Gilgandra populations may belong to a separate species.

This species is morphologically close to *P. gymnonota* Hammer, described from New Zealand (Hammer, 1966), but differs in lacking a caudal notch in the notogaster and in the shorter length of the stalk supporting the claw complex.

**Distribution.** Coastal plains and ranges of northern New South Wales and southern Queensland; riverine plains of western New South Wales; Parilla area, South Australia.

### *Pedrocortesella subula* n.sp.

Figs 41, 42

**Type material.** Queensland: HOLOTYPE adult, ANIC, 2 km W. of Chillagoe, 17° 09'S 144°31'E, deciduous vine thicket, 330 m, ANIC litter berlesate 341, Taylor & Feehan, 28 June 1971. PARATYPES: AM KS43672, same data as holotype, 2 adults; QM, same data, 2 adults; WAM, same data, 2 adults; ANIC, same data, 44 adults; FMNH, same data, 2 adults; CNC, same data, 2 adults; AM KS46526 SEM stub no. S/203 (ill.), same data, 4 adults; AM KS46527 SEM stub no. S/206 (ill.), same data, 3 adults; AM KS46528 SEM stub no. S/342 (ill.), same data, 3 adults.

**Other material examined.** Western Australia: AM KS46529, SEM stub no. S/110 (ill.), 14 km S. by E. of Kalumburu Mission, CALM site 4/3, 14°25'S 128°40'E, closed forest, litter, ANIC berlesate 1076, T.A. Weir, 3–6 June 1988, 5 adults; AM KS43673, same data, 8 adults; WAM, same data 7 adults; ANIC, same data, 10 adults; AM KS46530, SEM stub no. S/159 (ill.), 5.6 km W. of Evelyn Island, 14°07'S 127°31'E, rainforest, berlesate litter, CALM site 10/2, CALM staff, 25–31 January 1989, 4 adults; WAM, same data, 1 adult; AM KS43674, same data, 2 adults.

**Diagnosis.** Body medium sized, length about 600–650 µm; scalps rarely (if at all) carried by adult; sensillus with long flattened tuberculate blade; notogaster densely punctate, with caudal notch when viewed from above, 5 pairs of notogastral setae, with cerotegument they are

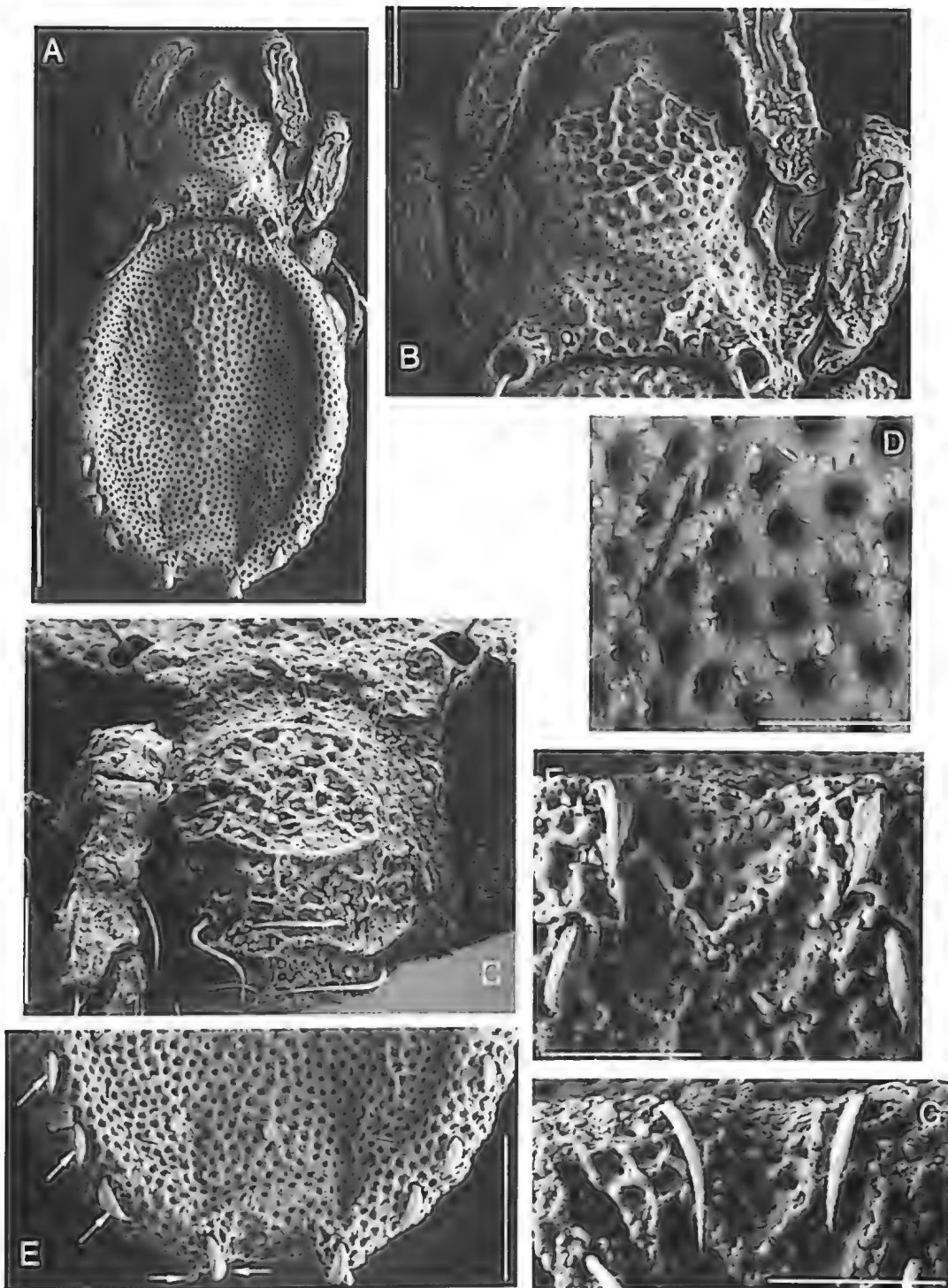


Fig. 41. *Pedrocortesella subula* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, prodorsum, frontal; D, notogastral integument and fissura *im*; E, notogaster, posterior, dorsal, arrows right to left label setae *hl*, *pl*, *lp<sub>x</sub>*, *p2<sub>x</sub>*, *p3<sub>x</sub>*; F–G, notogastral setae *hl* and *pl*, posterior view. Scale bars: A = 100  $\mu$ m; B, C, F, G = 50  $\mu$ m; D = 20  $\mu$ m. A, B, D–F = Chillagoe; C = Evelyn Island; G = Kalumbure Mission.

leaf-shaped; genital and anal vestibules close; genitoanal chaetotaxy 7:1:2:3, genital setae in slightly arcuate file, level of insertion of *ad3* at about half length of anal valve; claw stalk short.

### Description

**ADULT:** *Body:* brownish; length of 2 specimens from Chillagoe is 600  $\mu$ m, 645  $\mu$ m. *Cerotegument:* body generally with thin veneer of cerotegument; reticulations on prodorsum and notogaster and rim of bothridium

highlighted with cushion-like tubercles of cerotegument which may coalesce into crests; basic stellate nature of tubercles evident in side view (Fig. 42D). Setae *ro* and *le* and notogastral setae without obvious cerotegument. Legs with cerotegument capping the reticulate surface ornamentation which is of much lower relief than in *P. propinqua*. *Prodorsum:* integument divided into 3 fields: rostral field with loose reticulation pattern with some crests coalescing into a carina anterior to and posterior to setae *le*; a strongly reticulate-alveolate field anterior to median transverse furrow, alveoli perforated

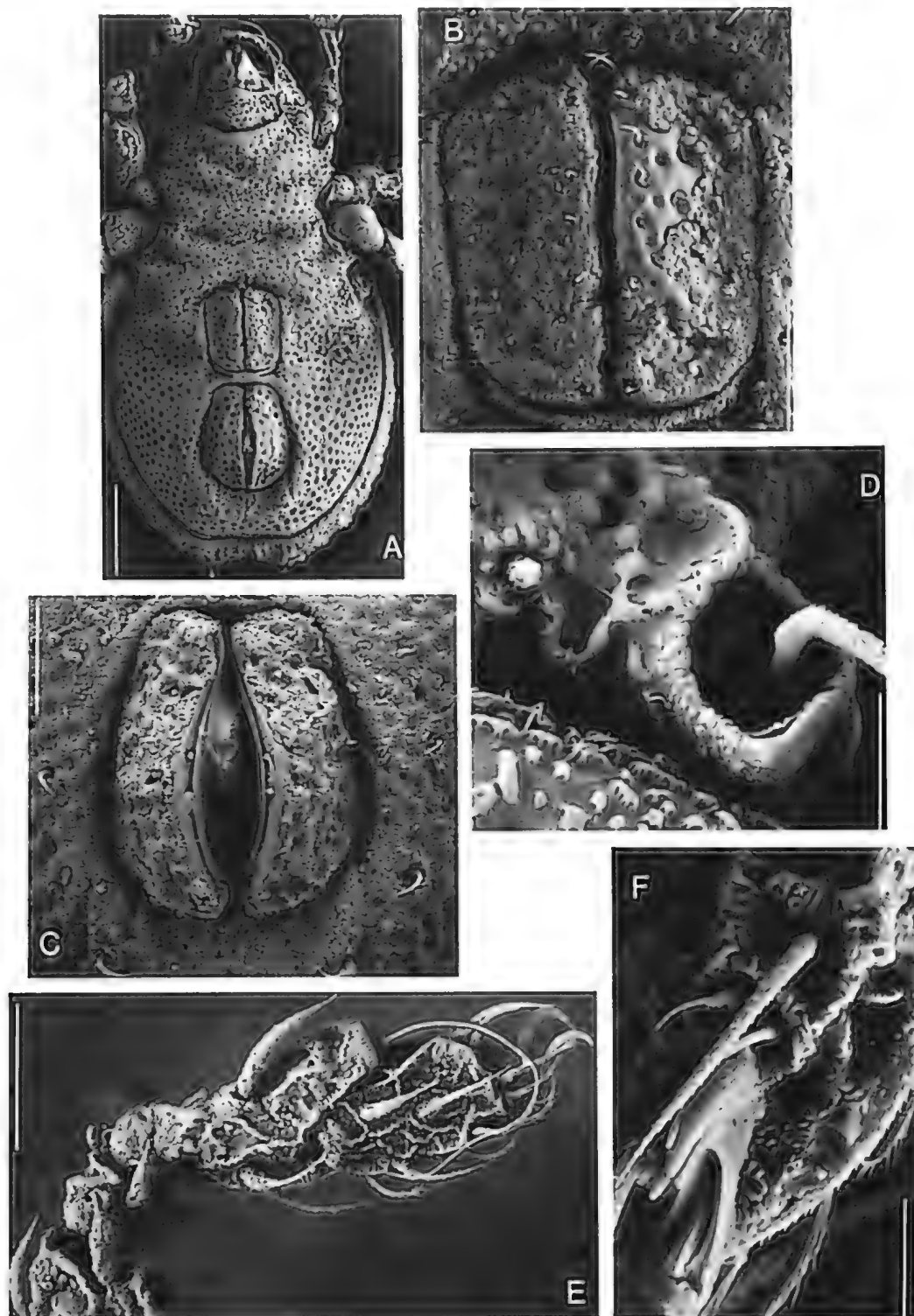


Fig. 42. *Pedrocortesella subula* n.sp. A, body, ventral; B, genital valves; C, anal valves. D, Bothridium and seta *in*, dorsal; E, leg I, genu, tibia and tarsus, antiaxial; F, detail tarsal cluster, dorsal. Scale bars: A = 100  $\mu$ m; B,C,E = 50  $\mu$ m; D,F = 20  $\mu$ m. A–C,E,F = Chillagoe; D = Kalumbure Mission.

by pore; a bothridial field with reticulations, pores and carinae (Fig. 41B). *le* dorsolateral, distance between them about 0.7 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal tooth similar to *P. propinqua*. Bothridium abutting notogaster (Fig. 42D), wall more rounded than in *P. propinqua*; posterolateral carina weak, carina of similar strength anteriorly, bothridium abutting but not closely adpressed to notogaster; sensillus length about 0.75 interbothridial

distance, with long flattened tuberculate blade. *in* small, set almost one bothridial diameter from bothridial rim and somewhat away from dorsosejugal suture level with anterior of bothridium, spiniform but largely encased in cerotegument (Fig. 42D). *Exuvial scalps*: none seen. *Notogaster*: oval but wide, length:width 425:330. Intramarginal depression oval; central plateau weakly developed. Dorsum densely punctate (Fig. 41A,D). Posterior margin weakly invaginate when viewed from



above, with weak mesal carina ventral to setae *p1* when viewed posteriorly. Fissura small; *ia* and *im* oblique and *ip* perpendicular to sagittal plane. 5 pairs of conspicuous awl-shaped notogastral setae; *h1* very widely separated, not converging at their tips, each located just inside posterior margin; *p1* inserted high on posterior flank, further apart than *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise inside posterolateral flank, their insertions clearly visible from above, *lp<sub>x</sub>* and *p2<sub>x</sub>* equidistant to fissura *ip*, *lp<sub>x</sub>* inserted posterior to it (Fig. 41E). *Gnathosoma*: pedipalp not examined. Rutella basally with moderate concave flexure and moderate lateral buttressing, pointed mesad processes and transverse striations absent. *Epimeral region*: convex immediately anterior to genital valves though not tending to overhang them. *Genitoanal region*: separation of anal and genital vestibules relatively narrow with deep transverse grooves and a narrow isthmus between the vestibules (Fig. 42A). Entire venter punctate, though less densely than notogaster. Genitoanal chaetotaxy 7:1:2:3; genital setae in slightly arcuate file, *g1* slightly longer than other setae, inserted near inner anterior corner; *g5* situated at about 0.5 valve length, *g7* inserted anterior to inner posterior corner, not in notch; setae *ag* inserted at level posterior to *g6*; setae *ad1* distinctly postanal, more so than *P. propinqua*, *ad3* level with about 0.5 length of anal valve. *Legs*. Distal apophysis of tibia overlaps about 50% of tarsus (Fig. 42E). Tarsal cluster of leg I placed distodorsally on apophysis, above and slightly proximal to setae *tc*; *ft*" enclosed in its own rim; *omega 1* and 2 within a separate rim, widely separated and shorter than *ft*"; tarsus lacking distal recess for receiving retracted unguinal complex, stalk short.

**Variation.** The two populations in Western Australia have thinner leaf-shaped notogastral setae due to a lesser accumulation of cerotegument (Fig. 41G).

**Comments.** *Pedrocortesella subula* appears most closely related to another northern Australian species, *P. calmorum*, in the form of the notogaster, but differs in having leaf-shaped notogastral setae and less body cerotegument.

**Etymology.** The specific epithet is a Latin noun in apposition meaning "awl" in reference to the shape of the notogastral setae.

**Distribution.** Tropical northern Australia.

### *Pedrocortesella temperata* P. Balogh

Figs 1B, 43–45

*Pedrocortesella temperata* P. Balogh, 1985: 51–53, fig. 3.

**Type material.** New South Wales: HOLOTYPE adult, ANIC, Barrington Tops, near Salisbury, *Nothofagus moorei* leaf litter, temperate rainforest, 1520 m, G. B. Monteith, 10 February 1965. PARATYPES, ELU, same data, 10 adults. Not examined.

**Other material examined.** New South Wales: AM KS43686, Mount Allyn, near Barrington Tops, 32°08'S 151°26'E, bark scraped from *Nothofagus*, temperate rainforest, G.S. Hunt, 20 Sept. 1993, 18 adults; AM KS46549 SEM stub no. S/332 (ill.) same data, 4 adults; QM, same data, 2 adults; ANIC, same data, 2 adults; SAMA, same data, 2 adults; WAM, same data, 2 adults; FMNH, same data, 2 adults; CNC, same data, 2 adults; ZMK, same data, 2 adults; ANIC, Mount Banda

Banda, 42 km W.S.W. Kempsey, 31°10'S 152°26'E, 1050 m, moss under *Nothofagus*, ANIC berlesate 672, K.R. Pullen, 5 November 1980, 14 adults; AM KS46550, SEM stub no. S/116 (ill.), same data, 4 adults; AM KS43687, 15 km S. of Kempsey, 32°12'S 151°49'E, dry sclerophyll, berlesate leaf and bark litter under *Eucalyptus*, G.S. Hunt, 18 July 1992, 17 adults; AM KS46551, SEM stub no. S/143 (ill.), same data, 1 adult; AM KS46552, SEM stub no. S/146 (ill.), same data, 3 adults; AM KS43688 3 km E. of Bell, Bells Line of Road, 33°30'S 150°17'E, berlesate leaf litter, dry sclerophyll, G.S. Hunt, 21 June 1992, 39 adults; AM KS43689, West Head, Ku-ring-gai Chase National Park, Challenger Track, ca 33°35'S 151°18'E, remnant gully rainforest, berlesate, J. Thompson and M. Gray, 24 November 1992, 1 adult; ANIC, Echo Head Falls, Kanangra-Boyd National Park, 33°59'S 150°06'E, ANIC berlesate 856, litter near creek, L.Hill, 3 October 1982, 27 adults.

Victoria: CNC, Mitchell River Site MR1A-6, Mitchell River Environmental Survey of Museum of Victoria, 1 October 1975, 1 slide-mounted adult.

South Australia: ANIC, 86 km S of Meningie, ca 36°22'S 139°45'E, leaf litter in sandy soil, ANIC berlesate 74, E.B. Britton, 30 April 1968, 2 adults.

**Diagnosis.** Body medium-large, length about 650–750 µm; scalps carried by adult, scalps with caudal apophysis bearing setae; sensillus long flattened tuberculate blade; notogaster reticulate-alveolate, 5 pairs of notogastral setae; genitoanal chaetotaxy 7:1:2:3, 6 pairs genital setae essentially in straight file near inner lip, *g5* markedly offset laterad to *g4*, insertion of seta *ad3* adjacent to anterior 50% of anal valve; claw stalk very short.

### Description

**ADULT: Body:** dark brown; length (µm) with scalps 710, 710, 740, 760, 770; without scalps 650, 660, 670, 670, 710, 720. **Cerotegument:** body generally with thin veneer of cerotegument; reticulations on prodorsum, notogaster, rim of bothridium and legs highlighted with crests of cerotegument (Fig. 43D), though subdued on notogaster beneath scalps. Setae *ro* and *le* and notogastral setae with cerotegument at their bases. **Prodorsum:** integument reticulate-alveolate particularly anterior to median transverse groove but less so on rostrum, alveoli without visible pores; carina between *le* and *ro* absent; *le* dorsolateral, distance between them about 0.60 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal tooth strongly curved anteriad, tapering abruptly subapically. Bothridium abutting notogaster but not closely adpressed (Fig. 43C), wall subcircular and depressed posteromesally and anterolaterally, posterolateral carina very weak, situated close to notogaster; sensillus length subequal to interbothridial distance, with long flattened tuberculate blade (Fig. 43D), posterior margin of prodorsum forming a smooth arc between bothridia. *in* small, set >0.5<1.0 bothridial diameter from to bothridial wall, at edge of dorsosejugal furrow, spiniform, base encased in cerotegument, directed largely posteriad (Fig. 43C). **Exuvial scalps:** habitually carried; tritonymphal scalp with prominent caudal process bearing conspicuous setae *p1* (Fig. 43F) **Notogaster:** oval, length:width without scalps 430:360, 440:360, 500:380, 520:400. Intramarginal depression oval. Notogaster weakly alveolate-reticulate beneath scalps but sculpturing more pronounced around flanks, not perforated by pores

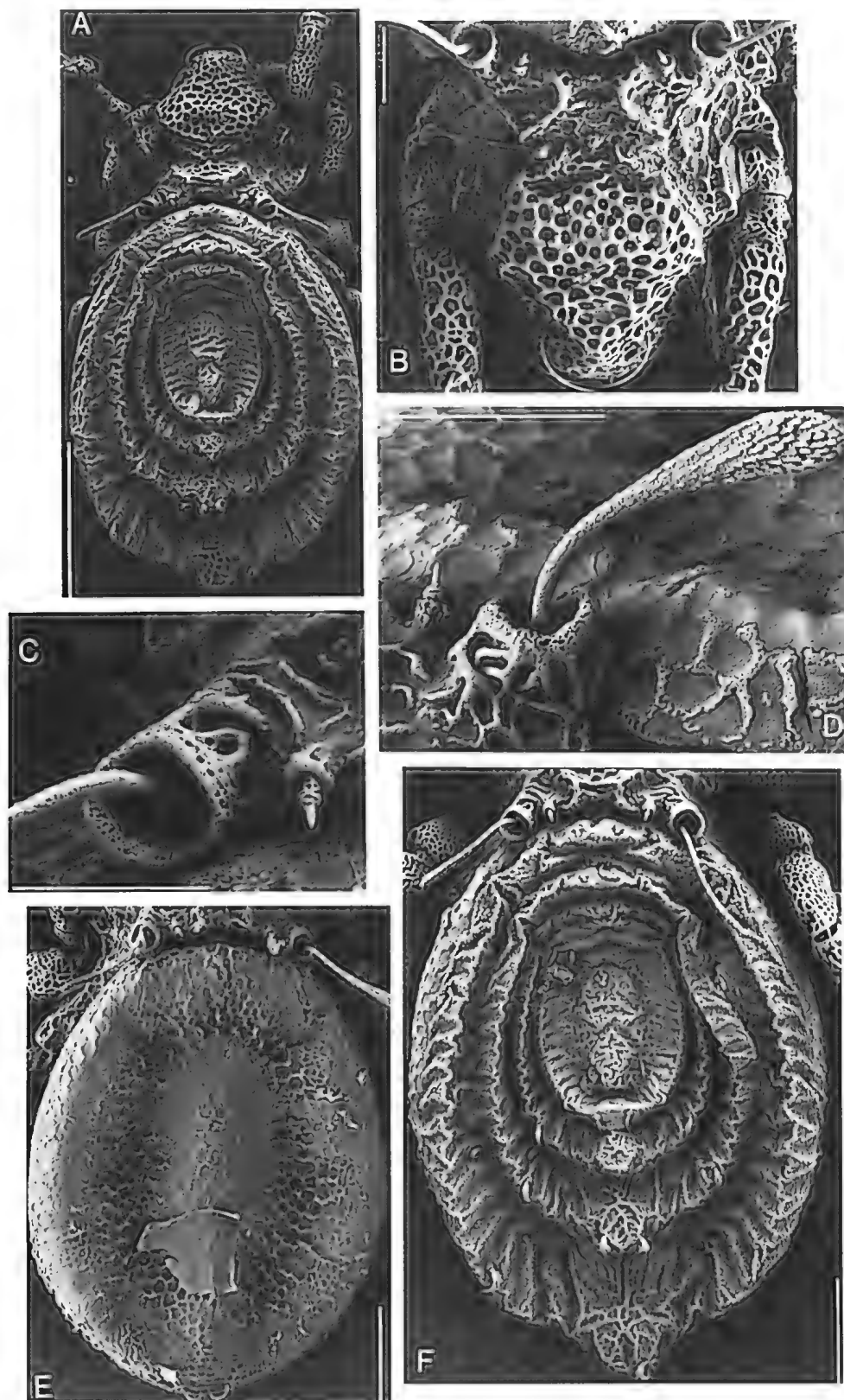
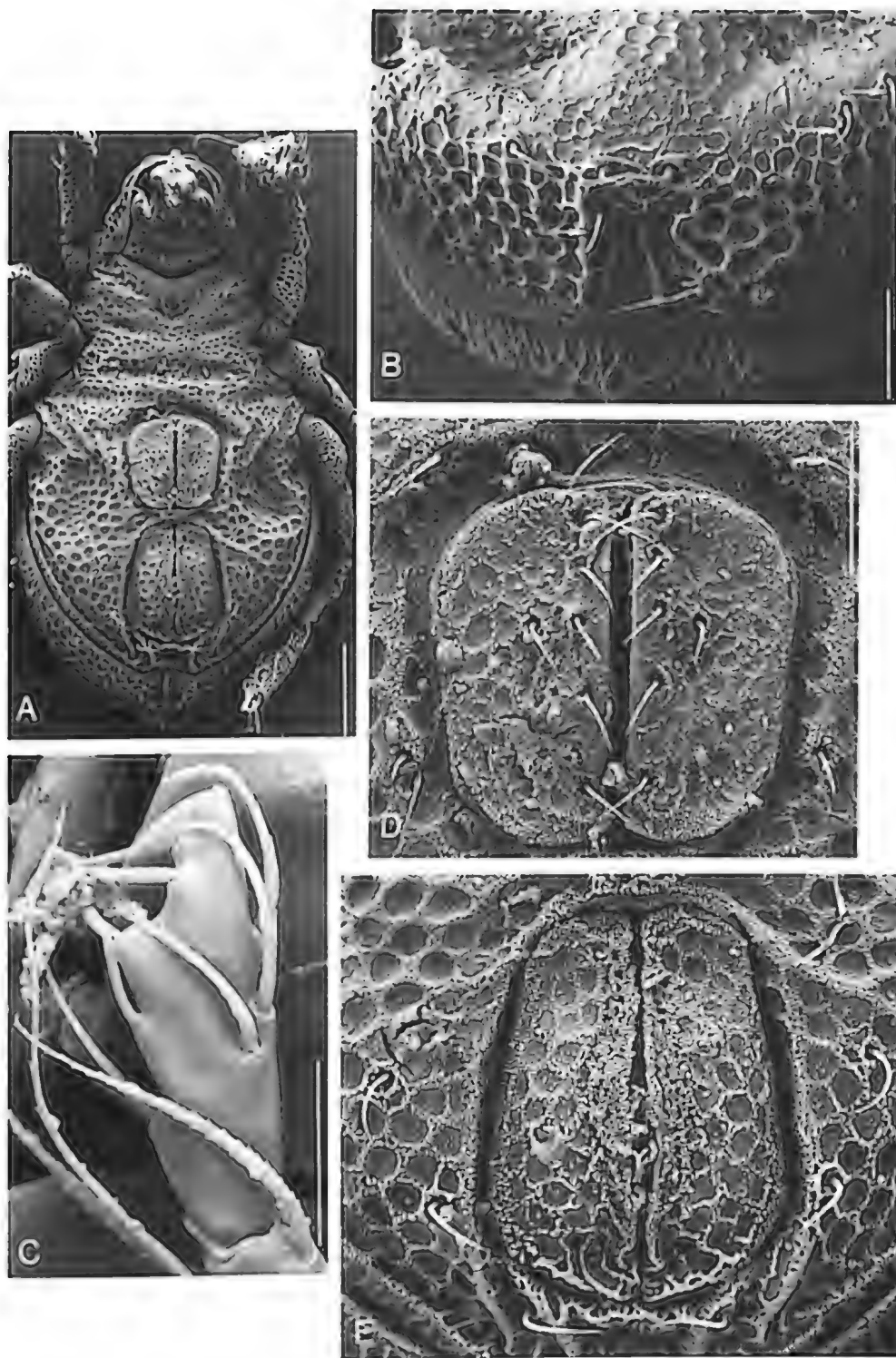


Fig. 43. *Pedrocortesella temperata* P. Balogh. A, body, dorsal; B, prodorsum, dorsal; C, bothridium and seta *in*, dorsal; D, bothridium, sensillus and seta *in*, lateral; E, notogaster (scalps removed); F, exuvial scalps. Scale bars: A = 200  $\mu$ m; B,E,F = 100  $\mu$ m; B-D = 50  $\mu$ m. A,C,D,F = Mount Allyn; B = Mount Banda Banda; E = Kempsey.

(Fig. 44B); posterior margin not invaginate when viewed from above, with weak carina between setae *p1* when viewed posteriorly (Fig. 44B). Fissura *ia*, *im* and *ip* subparallel-slightly oblique to sagittal plane; 5 pairs of short notogastral setae arising from small pits; *hl* close

to each other and strongly curved mesad, each located at posterior margin; *p1* inserted high on posterior flank, slightly further apart than *hl*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise along posterolateral flank, their insertions barely visible from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted posterior



**Fig. 44.** *Pedrocortesella temperata* P. Balogh. A, body, ventral; B, body, posterior, arrows right to left label setae  $p3$ ,  $p2$ ,  $h1$ ,  $p1$  and  $lp$  (on left side); C, pedipalp tarsus, antiaxial; D, genital valves; E, anal valves. Scale bars: A = 100  $\mu$ m; B,C,E = 50  $\mu$ m; D = 10  $\mu$ m. A,C,D,E = Mount Allyn; B = Kempsey.

to it (Fi. 34B). *Gnathosoma*: rutella basally with weak concave flexure and moderate lateral buttressing, pointed mesad processes and transverse striations absent (Fig. 45A). Pedipalp tarsus with setae  $l''$  and  $(vt)$  with moderately long side branches,  $cm$  branches very short; apophysis supporting seta  $acm$  low, solenidion  $\omega$  reaching above base of  $acm$  (Fig. 44C). *Epimeral region*: epimeral region weakly convex anterior to genital valves, not tending to overhang them (Fig. 44D). *Genitoanal region*: separation of anal and genital vestibules relatively

narrow with moderately wide isthmus between the vestibules (Fig. 44A). Ventral plate reticulate-alveolate. Genitoanal chaetotaxy 7:1:2:3; genital setae long, essentially in straight file but with  $g5$  markedly offset laterad to  $g4$  (Fig. 44D),  $g1$  long somewhat longer than other setae, inserted at anterior margin of valve well lateral to its inner corner;  $g7$  inserted well anterior to inner posterior corner, not in marginal notch; setae  $ag$  inserted at level between  $g6$  and  $g7$ ; setae  $ad1$  distinctly postanal,  $ad3$  level with anterior half of anal valve;  $ad1$ –



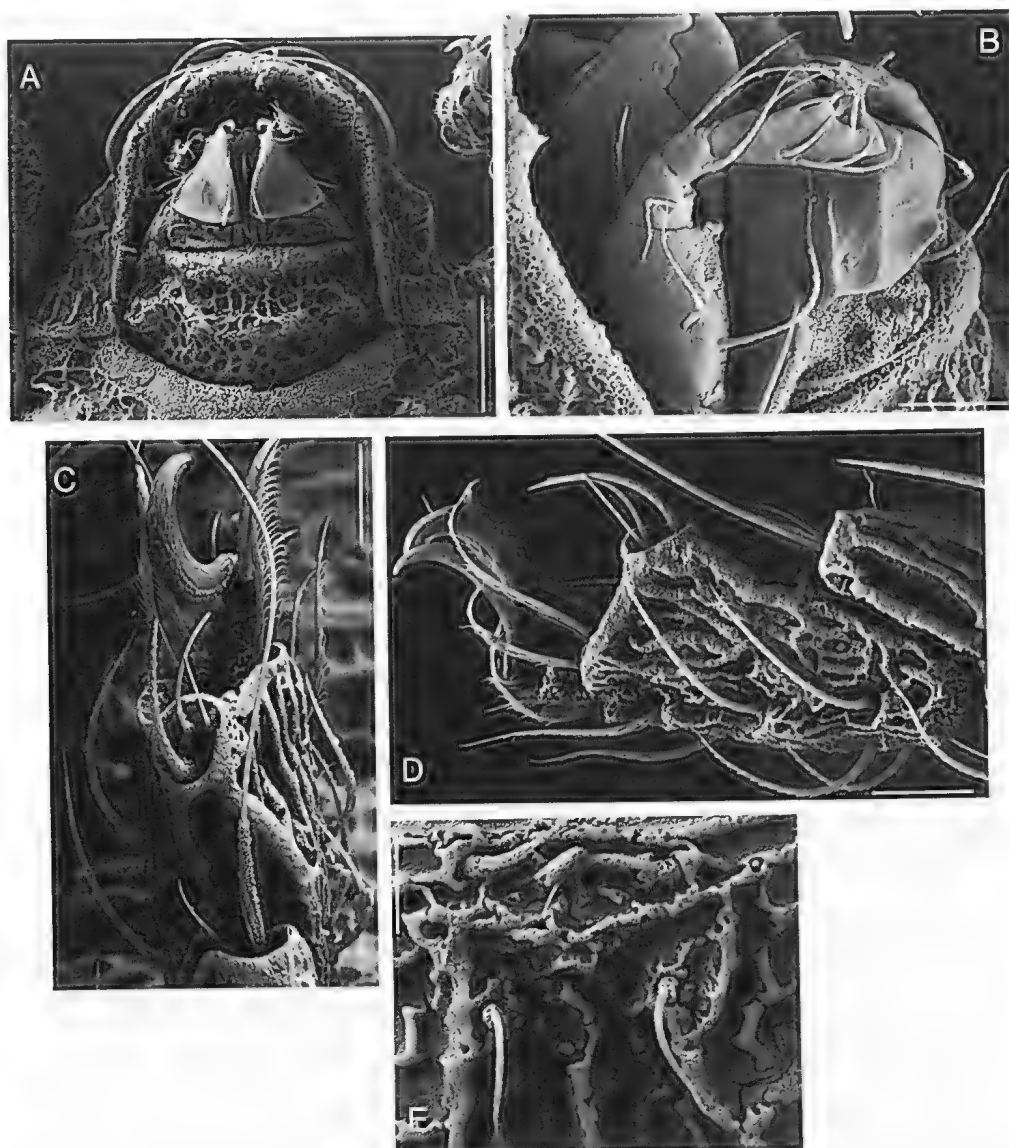


Fig. 45. *Pedrocortesella temperata* P. Balogh. A,B, subcapitulum, ventral and lateral; C,D, leg I tarsus, dorsal and lateral; E, notogastral setae *hl* and *pl*, posterior view. Scale bars: A = 50  $\mu$ m; B–E = 20  $\mu$ m. A,E = Mount Banda Banda; C–D = Mount Allyn.

3 inserted in small pits (Fig. 44E). *Legs*. Distal apophysis of tibia overlaps about 50% of tarsus (Fig. 45D). Tarsal cluster of leg I placed distodorsally on strong apophysis, *ft''*, *omega 1* and 2 enclosed in well-developed almost circular common rim (Fig. 45C), no partition separating *ft''* from *omega 1* and 2; tarsus with marked distal recess for receiving retracted unguinal complex, stalk very short (Fig. 45D).

**Comments.** The specimens from Ashbourne and Meningie in the semiarid mallee country of South Australia are very similar to the populations in the eastern coastal ranges of New South Wales. Within the coastal zone, populations occur in temperate and subtropical rainforest but also in dry sclerophyll habitats. The species can apparently tolerate a wide range of conditions and possibly has a continuous distribution between the eastern ranges of New South Wales and the occurrence in South Australia. This peculiar distribution is similar to that of *P. propinqua* and, as with this species, further study may reveal separate species. The Mitchell River

record in Victoria may represent an introduced or relictual population.

*Pedrocortesella temperata* can easily be confused with *P. cryptoreticulata* which also habitually retains its scalps, but differs in having a caudal apophysis on the scalps and in having a laterad seta on the genital valves. Scalp retention and a caudal apophysis also characterise *Labiozona queenslandica* (see Hunt, 1996c).

**Distribution.** Eastern New South Wales from Kanangra Walls area northwards to Kempsey area, with possible disjunct occurrences in South Australia and Victoria.

#### *Pedrocortesella truncata* n.sp.

Figs 13A, 46, 47

**Type material.** New South Wales: HOLOTYPE adult, AM KS46548, SEM stub no. S/133 (ill.), beside Pacific Highway, 15 km S. of Kempsey, 32°12'S 151°49'E, dry sclerophyll, berlese extraction leaf and bark litter at base of tree, G.S.Hunt, 18 July 1992.

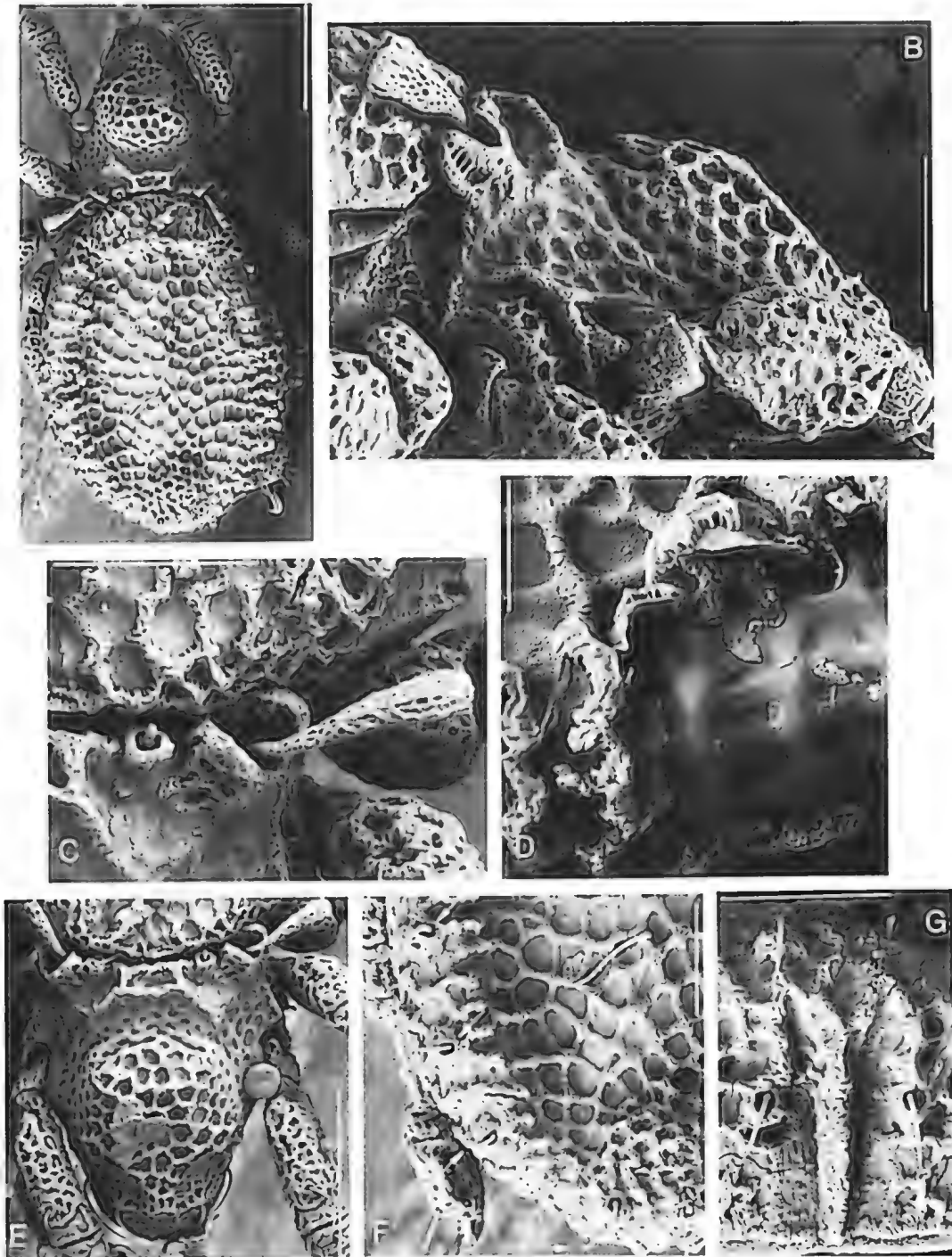


Fig. 46. *Pedrocortesella truncata* n.sp. A, body, dorsal; B, prodorsum, lateral; C, bothridium, sensillus and seta *in*, dorsal; D, notogastral integument; E, prodorsum, dorsal; F, part of posterior of notogaster, dorsal, arrows right to left label setae *h1*, *p1*, *lp*, *p2*, *p3*; G, notogastral setae *h1* and *p1*, posterior view. Scale bars: A,E = 100  $\mu$ m; B,C,F,G = 50  $\mu$ m; D = 20  $\mu$ m.

**Diagnosis.** Body medium, length about 500–550  $\mu$ m; scalps rarely (if at all) carried by adult; sensillus not long flattened blade, distally truncate and covered with a reticulate pattern, not tuberculate; notogaster strongly reticulate-alveolate; 5 pairs of notogastral setae, arising from pits; genitoanal chaetotaxy 7:1:2:3, genital setae essentially in straight file, level of insertion of seta *ad3* at about 0.5 anal valve length; claw stalk very short.

#### Description

**ADULT:** *Body:* brown; length 520  $\mu$ m. *Cerotegument:* body with conspicuous network of cerotegument reflecting

underlying reticulate pattern of integument (Fig. 46A,D). Setae *ro* and *le* and notogastral setae without obvious cerotegument. *Prodorsum:* integument reticulate, carina between *le* and *ro* absent; *le* dorsolateral and close to anterior of prodorsum, distance between them about 0.6 distance between *ro*, not arising from large pit, *ro* ventrolateral. Pedotectal tooth similar to *P. propinqua* (Fig. 46A,B). Bothridium strongly adpressed to notogaster (Fig. 46C), wall semicircular in dorsal view, strongly depressed anterolaterally and largely missing posteriorly, posterolateral carina strong, situated close to notogaster (Fig. 46B); sensillus length about 0.7 interbothridial

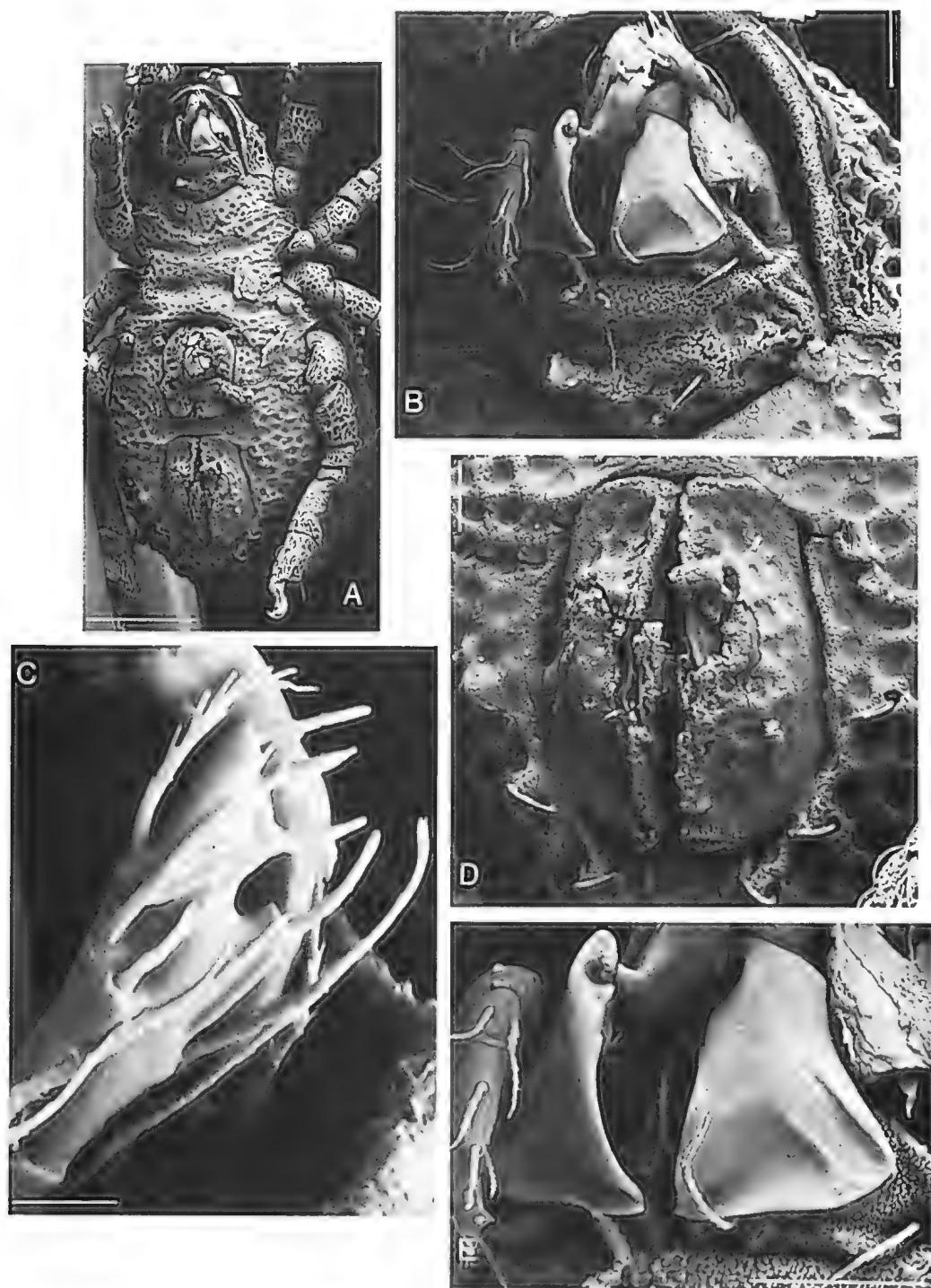


Fig. 47. *Pedrocortesella truncata* n.sp. A, body, ventral; B, subcapitulum; C, pedipalp tarsus, antiaxial; D, anal valves; E, rutella. Scale bars: A = 100  $\mu$ m; B,D,E = 20  $\mu$ m; C = 5  $\mu$ m.

distance, cuneiform with truncated lamina and reticulate surface ornamentation (Fig. 46B,C), posterior margin of prodorsum forming a smooth arc between bothridia. *in* small, set close bothridial wall, at edge of dorsosejugal furrow, spiniform (Fig. 46C). *Exuvial scalps*: none seen. *Notogaster*: oval, length:width 330:250. Intramarginal depression oval. Notogaster reticulate-alveolate, not perforated by pores (Fig. 46D); posterior margin not invaginate when viewed from above, with a strong carina between setae *pl* when viewed posteriorly (Fig. 46G). Fissura *ia* and *im* subparallel-oblique, *ip* perpendicular to sagittal plane; 5 pairs of short notogastral setae

arising from small pits, *hl* moderately close, each located just inside posterior margin; *pl* with slightly wider spacing than *hl*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise just inside posterolateral flank, their insertions visible from above, *lp<sub>x</sub>* closest to fissura *ip*, inserted posterior to it (Fig. 46F). *Gnathosoma*: rutella basally with strong concave flexure and a pair of strong buttresses laterally, small pointed mesad processes present, transverse striations absent (Fig. 47E). Pedipalp tarsus setae (*vt*) and *l''* with long barbs, *cm* short; apophysis supporting *acm* moderately strong; solenidion not reaching base of *acm* (Fig. 47C). *Epimeral region*: strongly convex a small distance

anterior to genital valves and not tending to overhang them. *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 47A). Ventral plate reticulate-alveolate. Genitoanal chaetotaxy 7:1:2:3; genital setae essentially in straight file, *g1* at anterior corner in marginal notch; *g5* situated at about 0.5 valve length, *g7* inserted well anterior to inner posterior corner in marginal notch; setae *ag* inserted at similar level to *g7*; setae *ad1* postanal, *ad3* level at about 0.5 anal valve length (Fig. 47D). *Legs*. Distal apophysis of tibia overlaps about 40% of tarsus (Fig. 13A). Tarsal cluster of leg I placed distodorsally on apophysis, slightly proximodorsal to setae *tc*; *ft*", *omega 1* and *2* enclosed in well-developed almost circular common rim, no partition separating *ft*" from *omega 1* and *2*; terminal setae tend to be flattened with barbs lining their margins; tarsus with slight distal recess for receiving retracted unguinal complex, stalk very short.

**Comments.** This species is very closely related to *P. bithongabela*, on the basis of integumental sculpturing and the presence of flattened terminal leg setae. It differs principally in having a truncated sensillus.

**Etymology.** The specific epithet refers to the unusual truncated sensillus.

**Distribution.** Known only from the type locality, central eastern New South Wales.

### General Discussion

Most of the 22 Australian species in *Pedrocortesella* can be arranged into five species groups.

The *propinqua* species group contains *P. propinqua* (south-eastern Australia), *P. bannisteri* (Western Australia), *P. cornuta* (South Australia), *P. enigma* (Tasmania) and *P. gymnonota* (New Zealand). The type species, *P. pulchra*, from Peru, may also be referable to this group of *Pedrocortesella*. This species group has genital setae arranged in an arcuate file, a wide separation of genital and anal vestibules and a relatively anterior position for setae *ad3*.

The *subula* species group contains *P. hardyi* from New Guinea and several of the species described in this work, particularly from Western Australia: *P. subula*, *P. calmorum*, *P. obesa*, *P. gunjina* and *P. callitarsus*. This group is based on a very narrow separation of anal and genital vestibules, genital setae arranged in a straight file, a tendency for a caudal notch in the notogaster, and a median position of setae *ad3*. *Pedrocortesella augusta*, which carries six pairs of notogastral setae, is tentatively placed in this group.

The *semireticulata* species group contains *P. semireticulata* (South Australia), and the following new species from south-east Australia: *P. impedita*, *P. anica*, *P. bithongabela* and *P. truncata*. It is characterised by having a wide separation of anal and genital vestibules, a median position for setae *ad3* and notogastral setae arising from pits.

The *leei* species group contains *P. leei* (New South Wales) and *P. nortoni* (Tasmania). It is characterised by two pairs of adanal setae and a relatively short and thick sensillus.

The *kanangra* species group contains *P. kanangra*

(New South Wales) and *P. conundrum* (Tasmania). It is characterised by having a very wide separation of anal and genital vestibules with little interruption to the ventral plate microsculpture, six pairs of notogastral setae, six pairs of genital setae in an arcuate file, a posterior position for setae *ad3*, a reticulate-alveolate notogaster, and ventral keels to leg femora. The group appears to be closely related to three South American species, *P. montis* Fernandez, *P. monicae* Eguaras, Martinez & Fernandez and *P. tristius* Eguaras, Martinez & Fernandez which have genital setae in an arcuate file, six pairs of notogastral setae and a reticulate-alveolate notogaster. These species, however, have a more narrow separation of anal and genital vestibules, seven pairs of genital setae and lack strong ventral keels on the leg femora.

The relationships of *P. cryptoreticulata* and *P. temperata* are more uncertain and they do not fall clearly into any of the above species groups. Although both habitually carry scalps, the difference in separation of anal and genital vestibules in the two species, suggest they are not very closely related to each other. Furthermore, the caudal setae of the tritonymphal scalp in *P. temperata* are on apophyses, a condition resembling that in *Labiogena queenslandica* (see Hunt, 1996c).

The five putative species groups discussed above suggest there have been at least an equal number of radiations within *Pedrocortesella*. A phylogenetic analysis may provide justification for elevating some of the groups to the status of subgenera or genera. Present day distributions suggest that the *propinqua* group radiation may have had an origin which predated the split of the Gondwanan fragment of South America-Antarctica-Australia-New Zealand.

The disposition of notogastral setae in *P. conundrum* is of interest as a possible case of neoteny. The form of the notogaster in this species is typical of *Pedrocortesella* but the nymphal distribution of setae *p2* and *p3* is largely retained in the adult, as occurs in *Pheroliodes*. Normally in *Pedrocortesella*, these setae occur on the posterior flank in nymphs but migrate to the dorsal surface during development of the adult. Alternatively, this species may retain less derived positions for setae *p2* and *p3*.

*Pedrocortesella* species in Australia are readily extracted from leaf-litter and soils in drier habitats, for example dry sclerophyll forest and semiarid woodland. They are uncommon in ground samples in moister environments, such as rainforest. In these latter environments, however, some species can be readily extracted from bark samples from trees where the moisture regime is probably more similar to ground situations in the drier habitats. Thus, *P. temperata* is common both in soils in dry sclerophyll forest and on tree trunks in rainforest. However, only two species, *P. nortoni* and *P. enigma*, seem to have evolved the rounded, ovoid sensillus, regarded as an adaptation to the arboreal habitat.

Collections of oribatids studied by taxonomists in South America and southern Africa seem to have been made mostly from soils in moister habitats. It is predicted that greater effort in drier soils and on trees in moister environments will reveal a richer *Pedrocortesella* fauna in these areas. The small amount of work done on the group in the eastern Palearctic suggests that a diverse fauna occurs there as well.



A phylogenetic analysis of the World fauna is likely to lead to a reappraisal of generic boundaries in the Plateremaeoidea, including those in *Pedrocortesella*.

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## A Review of the Genus *Hexachaetoniella* Paschoal in Australia (Acarina: Cryptostigmata: Pedrocortesellidae)

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**ABSTRACT.** The paper reviews the genus *Hexachaetoniella* Paschoal in Australia and a rediagnosis is given for the genus. One new combination is established: *H. dispersa* (*Pedrocortesella*) (P. Balogh, 1985), and the species is redescribed. Three new species are described: *H. bunya* n.sp., *H. contigua* n.sp. and *H. norfolkensis* n.sp. A key is given for the 5 species, including the type species *H. sexpilosa* (Hammer) from New Zealand. *Pedrocortesella japonica* Aoki & Suzuki, assigned by Paschoal (1987) to *Hexachaetoniella*, is regarded as *incertae sedis*.

HUNT, GLENN S., 1996. A review of the genus *Hexachaetoniella* Paschoal in Australia (Acarina: Cryptostigmata: Pedrocortesellidae). Records of the Australian Museum 48(3): 287–302.

Australian plateremaeoid mites have been reviewed by Hunt & Lee (1995) and Hunt (1996a). With recognition of the importance of arboreal mites in Australian forest ecosystems (Walter, 1995), a significant oribatid component is starting to be identified, including the plateremaeoid genus *Hexachaetoniella* Paschoal. Other predominantly arboreal plateremaeoids, such as *Novazelandiella* Paschoal, are the subject of a further paper (Hunt, 1996b).

The genus *Hexachaetoniella* was erected by Paschoal (1987) as part of his extensive revision of the Plateremaeoidea. The genus was based largely on two characters displayed by the type species, *H. sexpilosa* (Hammer), and by *H. japonica* (Aoki & Suzuki): six pairs of notogastral setae and the arrangement of the genital setae in a straight file near the inner margin of the genital valve. Six pairs of setae, however, seem to have arisen independently in several *Pedrocortesella* species (P. Balogh, 1985; Eguaras *et al.*, 1990; Hunt

& Lee, 1995; Hunt, 1996a), while species with 5 pairs of notogastral setae can have genital setae arranged in either a straight or arcuate file (Hunt & Lee, 1995; Hunt, 1996a).

Re-examination of *H. sexpilosa* and comparison with *Pedrocortesella dispersa* P. Balogh and three new species from Australia have enabled a redefinition of the genus based on the following diagnostic characters: placement of the "sixth" seta (seta *lm*) mesad of fissura *im*, and the presence of a raised integumental mound in the centre of most notogastral foveae. *Hexachaetoniella japonica* does not share these characters and its generic placement is uncertain.

*Hexachaetoniella* is known only from Australia, Norfolk Island and New Zealand. It is placed in the family Pedrocortesellidae Paschoal on the basis of the lack of enantiophyses on the prodorsum, two pairs of anal setae, and the dorsal placement of notogastral setae *p2* and *p3* (Hunt, 1996a).

## Methods

Descriptions apply to adults only. A Cambridge Stereoscan 120 with Robinson Detector was used for SEM. The holotype of described species have been examined. The following abbreviations are used to indicate the present location of material: AM—Australian Museum, Sydney; ANIC—Australian National Insect Collection, Canberra; CNC—Canadian National Collections of Insects, Arachnids and Nematodes, Ottawa; FMNH—Field Museum of Natural History, Chicago; QM—Queensland Museum, Brisbane; ZMK—Zoologisk Museum, København.

Specimens are preserved in alcohol unless otherwise stated.

Many structures referred to in descriptions and the key are illustrated with their abbreviations in Figure 1 of Hunt (1996a). Measurements are in micrometers and ratios of notogaster length to width in species descriptions are given in the actual measures, e.g., 540:460, for each specimen measured. The ratio is presented as 1.2:1, etc. in the key and diagnoses. The abbreviation "ill." means the specimen was used in illustrations.

Paschoal (1987) seems to have numbered genital setae from posterior to anterior, rather than by the normal convention of anterior to posterior, which is followed here.

## Character Descriptions

Hunt (1996a) has discussed and illustrated the taxonomic characters of the *Pedrocortesellidae*. The following discussion treats some characters of special relevance to *Hexachaetoniella*.

**Seta *lm*.** The position of seta *lm* or its alveolus immediately mesad and slightly posterior to fissura *im* is diagnostic for the genus. This seta is sometimes difficult to observe. It is uncertain whether the type species, *H. sexpilosa*, possesses the modified leaf-like seta shared by Australian (including Norfolk Island) species. This seta may have been broken off in the two type specimens as commonly occurs in Australian material.

**Other notogastral setae.** Setae *h1*, *p1*, *lp<sub>x</sub>* and *p2<sub>x</sub>* are inserted posterior to fissura *ip* (*p2<sub>x</sub>* lateral or slightly posterior to *ip* in *H. norfolkensis*); *p3<sub>x</sub>* is inserted lateral or anterior to *ip*. In *Pedrocortesella*, both *p2<sub>x</sub>* and *p3<sub>x</sub>* are invariably situated anterior to fissura *ip*.

**Central raised integumental mound in notogastral foveae.** This is diagnostic for the genus. It is present in nearly all dorsal foveae but may be absent from foveae on the flanks.

**Dorsal foveae poorly developed adjacent to lateral margins.** This is a character for the genus which also

occurs in *Pheroliodes* (Hunt, 1996c) and *Labiogena* (Hunt, 1996b). This condition is less evident in *H. norfolkensis*.

**Setae *ag* inserted posterior to genital valves.** This is a diagnostic character for the genus. The seta is more posterior in the Australian species than in *H. sexpilosa*.

**Extreme distal compression of tarsus I.** This involves seta *ft*", solenidia, alveolus of famulus, *tc*", *it*" and *u*" being arranged vertically beneath one another and with the tarsal cluster directed distad and lying antiaxial to the retracted claw complex. It characterises the Australian species. The type species also has distal compression, though less extreme (Paschoal, 1987). The sclerotised ring surrounding the entrance to the cavity of the undeveloped famulus is directed distally.

**Solenidion *omega 1* longer than seta *ft*".** This character may be related to the arboreal habitat as it also occurs in certain other arboreal plateremaeoids (Hunt, 1996b). *Omega 2* may be longer than *ft*" as well.

**Ovoid, clavate head of sensillus.** This form of sensillus is generally regarded as an adaptation to arboreal habitats (O'Dowd *et al.*, 1991). The condition in *H. sexpilosa* seems intermediate between the rounded clavate sensillus and the flattened blade-like sensillus of most *Pedrocortesella* species. The smooth spoon-like extension of the petiole which supports the head (Fig. 3G) is only known to occur in *Hexachaetoniella* (at least its Australian species).

**Length of apophysis supporting seta *acm* of pedipalp tarsus.** The apophysis is long in the two Australian species studied, and is much longer than in *Pedrocortesella* species, but similar to that in *Labiogena* Hunt (Hunt, 1996b).

**Smooth seta *l*" on pedipalp tarsus.** This character occurs in at least two species of *Hexachaetoniella*. A barbed seta is the usual condition in *Pedrocortesella* and *Pheroliodes*, though a smooth seta occurs in some other plateremaeoid taxa (Hunt, 1996b).

## *Hexachaetoniella* Paschoal, 1987

*Hexachaetoniella* Paschoal, 1987: 391; 1989b: 198; Balogh & Balogh, 1992: 48.

**Type species.** *Pedrocortesella sexpilosa* Hammer, 1966: 48, by original designation.

**Diagnosis.** Integument of notogaster foveate-reticulate, most dorsal foveae with raised central mound of integument; foveae mostly absent from dorsal margins of notogaster; 6 pairs of notogastral setae, seta *lm* or



its alveolus just mesad of fissura *im* often in form of broad leaf-like lamina; seta  $p2_x$  invariably inserted lateral or posterior to *ip*, never anterior to it; seta *ag* posterior to posterior margin of genital valves.

### Description

Plateremaeoid mites of medium to large size (length 590–750  $\mu\text{m}$ ); body covered with layer of cerotegument, reticular pattern and other high points usually with stellate and cushion-like mounds of cerotegument which often coalesce into crests; prodorsum with shallow transverse furrow but no enantiophyses; seta *le* lateral or dorsolateral, *ro* ventrolateral; seta *ex* absent; seta *in* small, spinous and arising from apophysis; bothridium abutting notogaster, its posterior wall complete, posterolateral carina very weak to virtually absent; sensillus short, distal part a short tuberculate blade, or an ovoid club somewhat rough or folded in appearance and supported by smooth spoon-like extension of sensillus petiole. Notogaster of adults ovate, sometimes carrying exuvial scalps; anterior margin of notogaster gently convex, forming angular transition with lateral margins; notogaster broadly convex in lateral aspect, inside the margin less steeply sloping or slightly concave, concave area ovate when viewed from above; integument foveate-reticulate, most of dorsal foveae with central raised plug; notogaster with 6 pairs of setae, seta *lm* or its alveolus inserted mesad of fissura *im*, unlike other setae it is often flat and leaf-shaped;  $p2_x$  lateral or posterior to *ip*, never anterior to it; setae  $lp_x$ ,  $p2_x$  and  $p3_x$  usually situated dorsally at the same general level as; *pl* situated on posterior flank ventral to *hl*; subcapitulum without

mental tectum; pedipalp tarsus seta *l*" smooth, apophysis supporting eupathidial seta *acm* moderate; epimeral chaetotaxy 3:1:3:3; anal and genital plates close; genitoanal chaetotaxy 7:1:2:3; genital setae forming straight line near inner margin of plate, not forming an arc; seta *ag* posterior to posterior margin of genital valves; setae *ad1* just anterior of posterior boundary of anal valves, setae *ad3* conspicuously most laterad; cerotegument on legs reticulate; distal compression usually strong, tarsal cluster on leg I usually directed distad and directly above setae (*tc*); sclerotised ring with hole marking the cavity containing the undeveloped famulus conspicuous ventral to solenidia, solenidion *omega 1* longer than seta *ft*"; leg tarsi heterotridactylous, laterals weaker than central prong; stalk long or short.

**Comments.** The Australian species are placed in *Hexachaetoniella* because of the close positional correspondence of seta *lm* to that in the type species and the possession of a central raised integumental mound in the notogastral foveae. *Pedrocortesella japonica* Aoki & Suzuki, 1970, assigned by Paschoal (1987) to *Hexachaetoniella*, does not share these characters and is regarded as *incertae sedis* pending phylogenetic analysis.

Curiously, Hammer (1966) does not describe or illustrate a seta near fissura *im* which is one of the six setae on which the specific epithet of her species, "*sempilosa*", is based. As acknowledged by Hammer (1966), the specific epithet was originally used by Ramsay (1959) for the same taxon in his unpublished description of "*Arthrodamaeus sempilosus*". Apparently, Hammer did not fully appreciate the significance of the name used by Ramsay.

### Key to adults of species in genus *Hexachaetoniella*

N.B., for identification under transmitted light the animal should be cleared. Scalps, if present, should be noted and removed to make examination easier.

- 1 Terminal expansion of sensillus flattened, seta *ag* about level with posterior margin of genital valves; New Zealand ..... *H. sempilosa* (Hammer)
- Terminal expansion of sensillus ovoid and clavate (Fig. 3G), seta *ag* about level with anterior margin of anal valves (Fig. 7B arrow) ..... 2
- 2 Separation between foveae on dorsal surface of notogaster about equal to half fovea diameter or much less than one fovea diameter (Fig. 3F) ..... 3
- Separation of foveae about equal to one fovea diameter or much greater than half fovea diameter (Fig. 6D) ..... 4
- 3 Notogastral length:width ratio about 1.4:1; Norfolk Island ..... *H. norfolkensis* n.sp.
- Notogastral length:width ratio between 1.1:1 and 1.3:1; Victoria and Tasmania ..... *H. contigua* n.sp.

- 4 Foveae on lateral flanks of notogaster well separated and with raised central mound (Fig. 1B); the three posterolateral notogastral setae not at same level on notogaster, one being set more ventrally (Fig. 1E); Bunya Mountain, south-eastern Queensland ..... *H. bunya* n.sp.
- Foveae on lateral flanks of notogaster close together and without raised central mound (Fig. 6C); the three posterolateral notogastral setae at same level on notogaster, one not being set more ventrally; southern New South Wales to central coastal Queensland ..... *H. dispersa* (P. Balogh)

### *Hexachaetoniella bunya* n.sp.

Figs 1, 2

**Type material.** Queensland: HOLOTYPE adult. AM KS46595 SEM stub no. S/111 (ill.), Barkers Track, Bunya Mountains National Park, 26°53'S 151°36'E, ANIC berlesate 847, L. Hill, 20 January 1982.

**Diagnosis.** Notogaster markedly convex; notogastral length:width ratio about 1.2:1; foveae absent on dorsum of notogaster just inside lateral and posterior margins but extend to anterior margin, most central foveae separated by more than their diameter; posterior notogastral setae *hl* weakly incurved; seta *p3<sub>x</sub>* inserted at posterior margin, its insertion just seen dorsally, *p2<sub>x</sub>* inserted ventral to *p3<sub>x</sub>* on posterior flank, its insertion not seen dorsally.

### Description

**ADULT: Body:** brown, sensillus black; length 610 µm. **Cerotegument:** most of body with a granulate film of cerotegument; foveae with granules of cerotegument on the central plug (Fig. 2C). Setae *ro* and *le* without conspicuous cerotegument (Fig. 1C). Legs with reticulate cerotegument reflecting integument. **Prodorsum:** integument largely foveate, most foveae with central plug, carinae between bothridia (Fig. 1D). *le* situated near front of rostrum; distance between them about 0.7 distance between *ro*, *ro* ventrolateral, no carina between *le* and *ro*. Pedotectal tooth gradually curving to blunt point. Prodorsum with transverse groove just anterior to transverse furrow. Bothridium close to dorsosejugal suture, directed dorsolaterad, rim subcircular and raised posteriorly, posterolateral carina very weak; sensillus club-shaped, its head lying just above bothridial rim (Fig. 1C). *in* small, set just inside edge of dorsosejugal furrow (Fig. 1D), spiniform but encased in cerotegument. **Exuvial scalps:** none seen. **Notogaster:** oval, length:width 420:350, more markedly convex in lateral view and rising more steeply from the margins to its highest point than *H. dispersa*. Central region of dorsum foveate but weak foveae also extending to anterior margin of notogaster, separation between foveae greater than their

diameter, number of foveae along mid-line about 20, along maximum width about 16, foveae with central plug (Fig. 1G), lateral and posterior marginal areas without foveae; flanks foveate, foveae with central plug (Fig. 1E). Posterior margin centrally not invaginate when viewed dorsally, shallow depression between *p1* when viewed posteriorly. Fissura *ia* and *ip* oblique, *im* perpendicular to sagittal plane. 5 pairs of notogastral setae verified; *hl* close at extreme posterior margin, short and weakly incurved (Fig. 1F), *p1* inserted at midheight on posterior flank, further apart than *hl*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* short, *lp<sub>x</sub>* near fissura *ip*, *p3<sub>x</sub>* inserted at posterior margin, its insertion just seen dorsally, *p2<sub>x</sub>* inserted ventral to *p3<sub>x</sub>* on posterior flank (Fig. 1E). Possible alveolus for seta *lm* located just mesad and posterad to fissura *ia* but seta itself not seen. **Gnathosoma:** pedipalp not studied. Rutella basally with weak concave flexure and moderate buttressing, without pointed mesad process; transverse striations absent. **Genitoanal region:** separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 3A). Aggenital and adanal areas and anal and genital valves foveate, most foveae with central plug. Strong cuticular thickening extending from adjacent to genital valve to near acetabulum of leg IV. Genital setae in straight file (Fig. 2D), all removed a short distance from mesal suture, *g1* inserted behind inner anterior corner, *g7* inserted near inner posterior corner; setae *ag* inserted posterior to genital valves, level with anterior margin of anal valves (Fig. 2C), setae *ad1* inserted just anterior to posterior margin of anal valves, *ad2* at or just anterior to posterolateral corner of anal valve, *ad3* conspicuously most laterad of adanal setae, level with about 0.5 of anal valve (Fig. 2C). **Legs.** Legs I missing, leg II (Fig. 2B).

**Comments.** An alveolus of seta *lm* seems to be present under the scanning electron microscope. However, this needs confirmation with fresh material.

**Etymology.** The specific epithet refers to the type locality.

**Distribution.** Bunya Mountain, south-eastern Queensland.

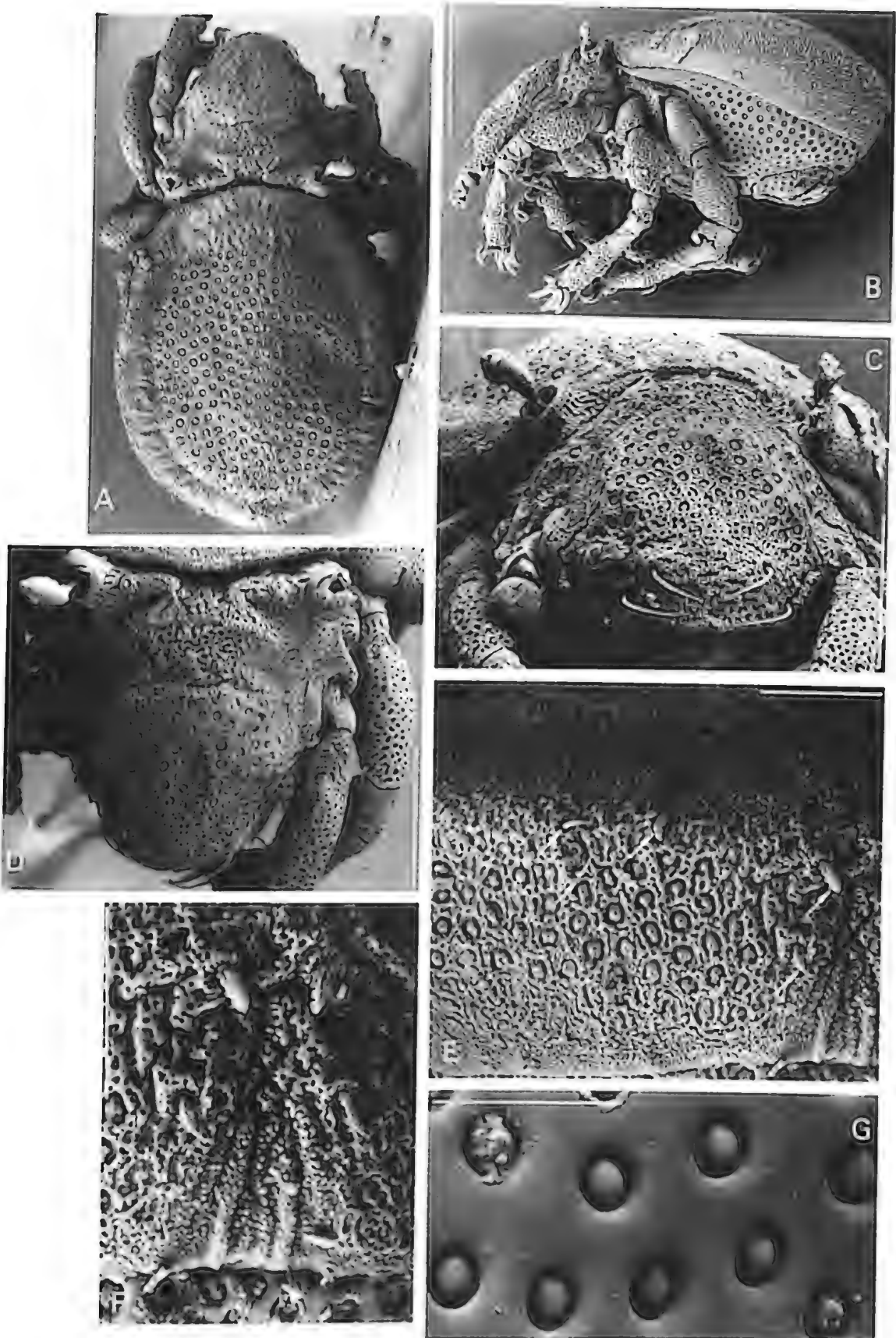


Fig. 1. *Hexachaetoniella bunya* n.sp. A,B, body, dorsal and lateral; C,D, prodorsum, frontal and dorsal; E, posterior view of notogaster, arrows right to left label setae *hl*, *pl*, *lp*, *p2* and *p3*; F, posterior notogastral setae *hl* and *pl*; G, notogastral integument with most cerotegument stripped away. Scale bars: A,D,E = 200  $\mu$ m; B,C = 100  $\mu$ m; F,G = 20  $\mu$ m.

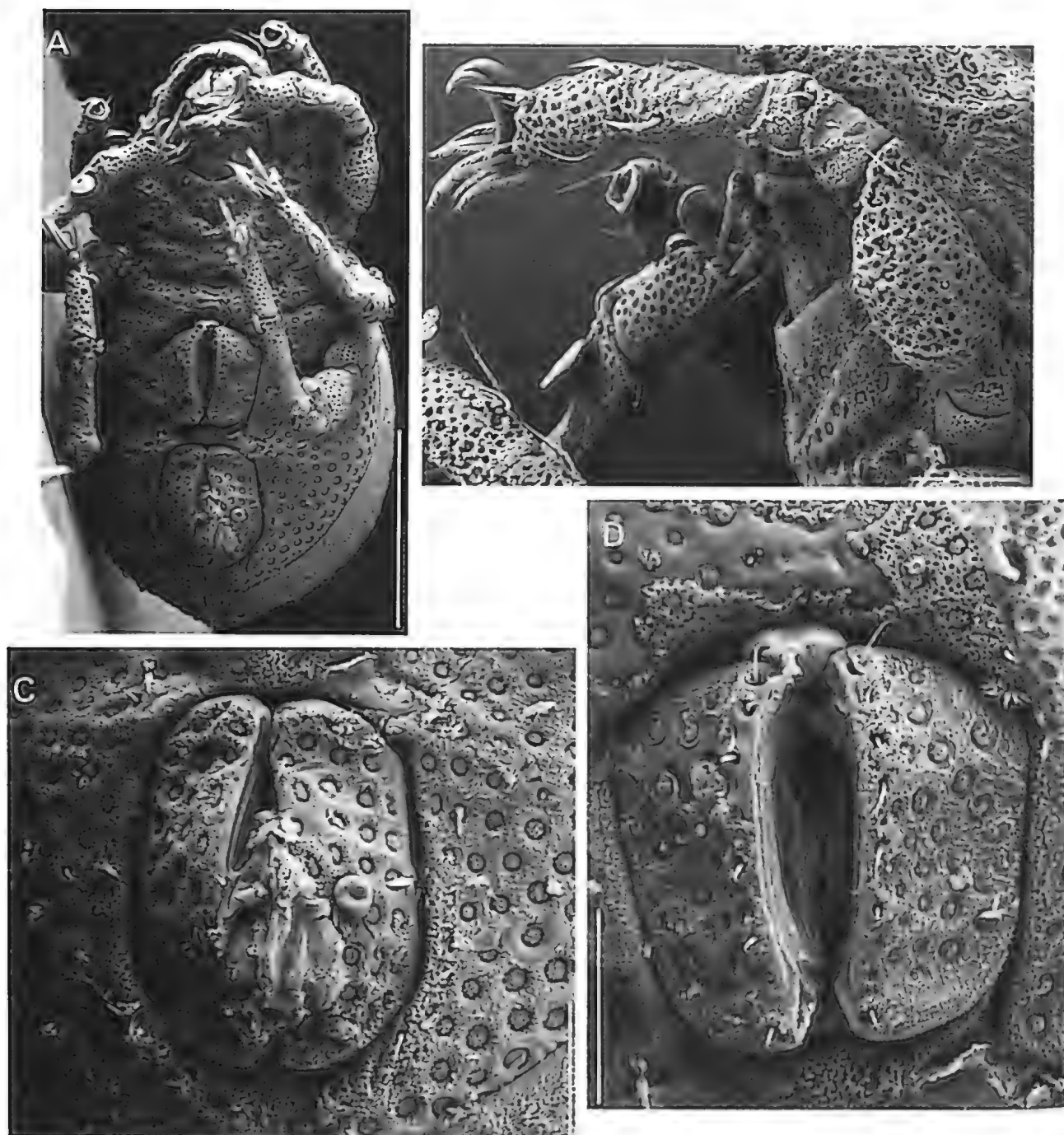


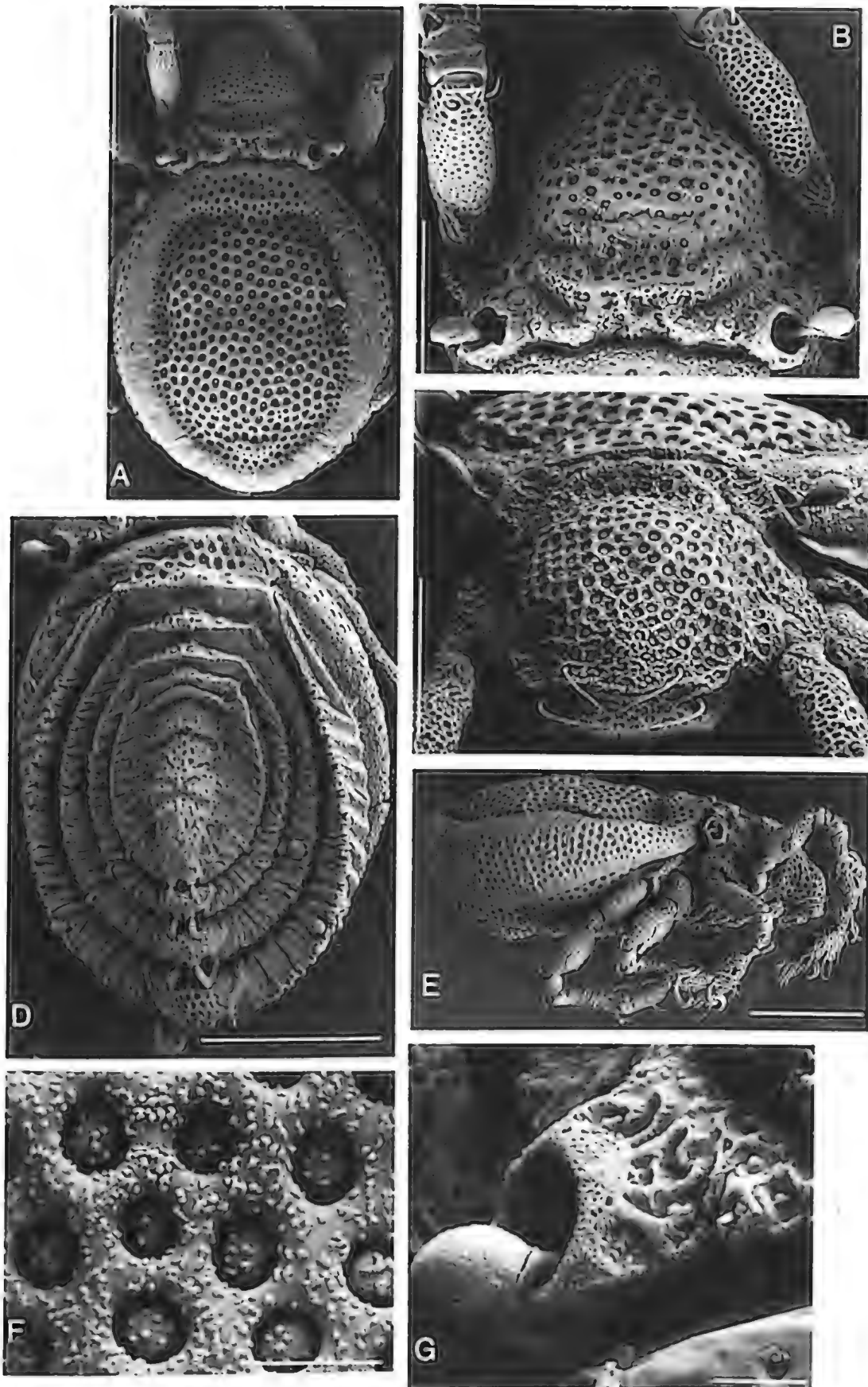
Fig. 2. *Hexachaetoniella bunya* n.sp. A, body, ventral; B, leg II, antiaxial; C, genital valves; D, anal valves. Scale bars: A = 100 µm; B–E = 50 µm; E = 20 µm; F = 10 µm.

*Hexachaetoniella contigua* n.sp.

Figs 3–5

**Type material.** Tasmania: HOLOTYPE adult. AM KS46581 SEM stub no. S/283 (ill.), Big Sassy Creek, 42°08'S 147°54'E, 400 m, rainforest site 2, pyrethrum knockdown, D. Rounsevell, 12 May 1989. PARATYPE adults. AM KS46582 SEM stub no. S/318 (ill.), Big Sassy Creek,

42°08'S 147°54'E, 400 m, rainforest site 2, pyrethrum knockdown, P. Greenslade, 12 May 1989, 4 adults; ANIC, same data, 8 adults; CNC, Mariette Falls, Mount Field National Park, ca 42°39'S 146°31'E, L. Masner, 13 January 1984, 1 adult; AM KS46583 SEM stub no. S/310 (ill.), Hellyer River Gorge, 41°16'S 145°36'E, temperate rainforest, L. Masner, 11 January 1984, 4 adults; AM KS43747, same data, 2 adults; FMNH, same data, 2 adults; ZMK, same data, 2 adults; CNC, same data, 27 adults.



**Fig. 3.** *Hexachaetoniella contigua* n.sp. A, body, dorsal; B,C, prodorsum, dorsal, frontal; D, exuvial scalps, dorsal; E, body, lateral; F, notogastral integument; G, bothridium, sensillus and seta *in*, dorsal (N.B., groove separating rough head from smooth petiole). Scale bars: A,D,E = 200  $\mu$ m; B,C = 100  $\mu$ m; F,G = 20  $\mu$ m. A,B,D-G = Big Sassy Creek; C = Otway Ranges.



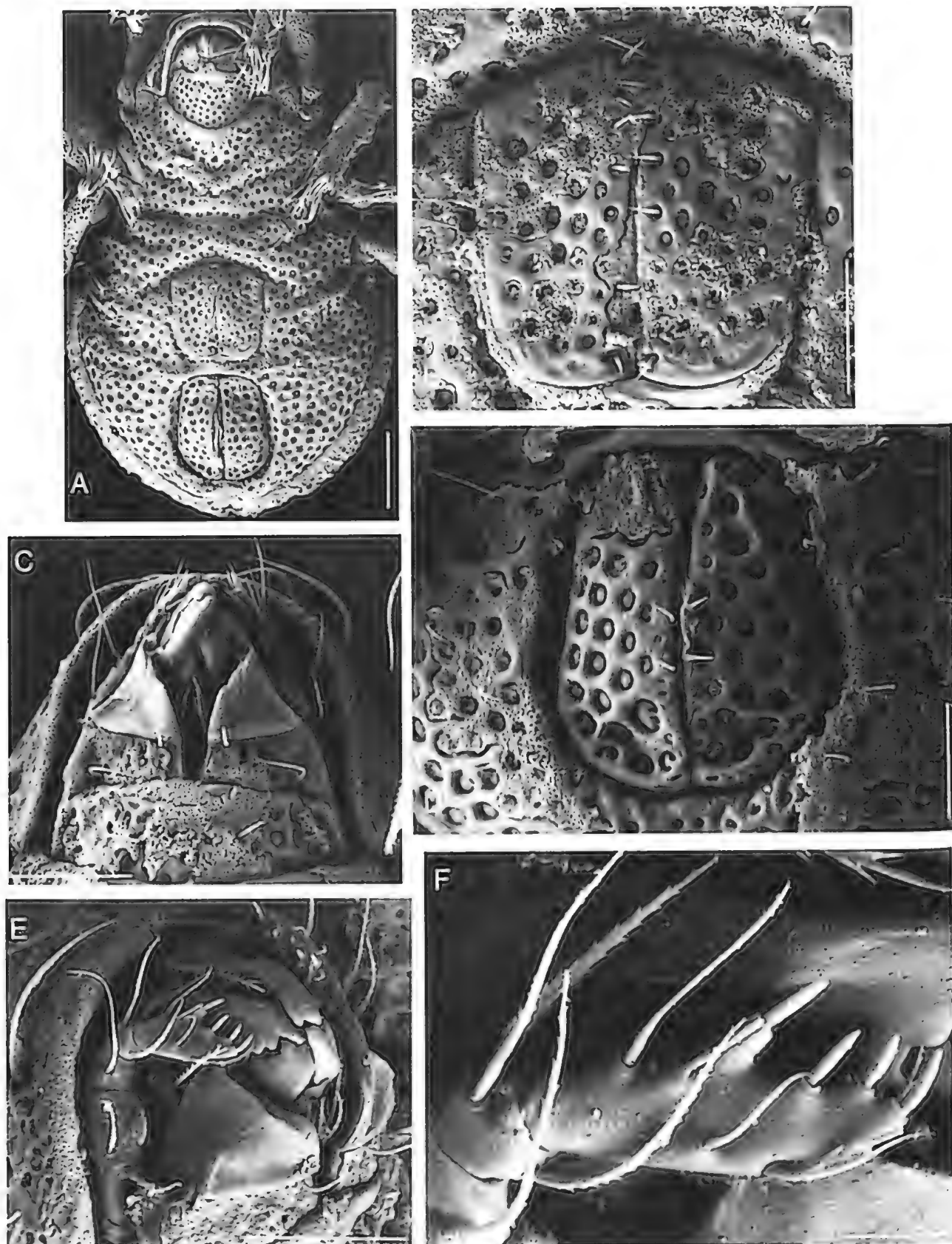


Fig. 4. *Hexachaetoniella contigua* n.sp. A, body, ventral; B, genital valves; C, subcapitulum; D, anal valves; E, subcapitulum, lateral; F, pedipalp, anti-axial. Scale bars: A = 100  $\mu$ m; B-E = 50  $\mu$ m; E = 20  $\mu$ m; F = 10  $\mu$ m. A-D = Big Sassy Creek; E, F = Cradle Mountain.

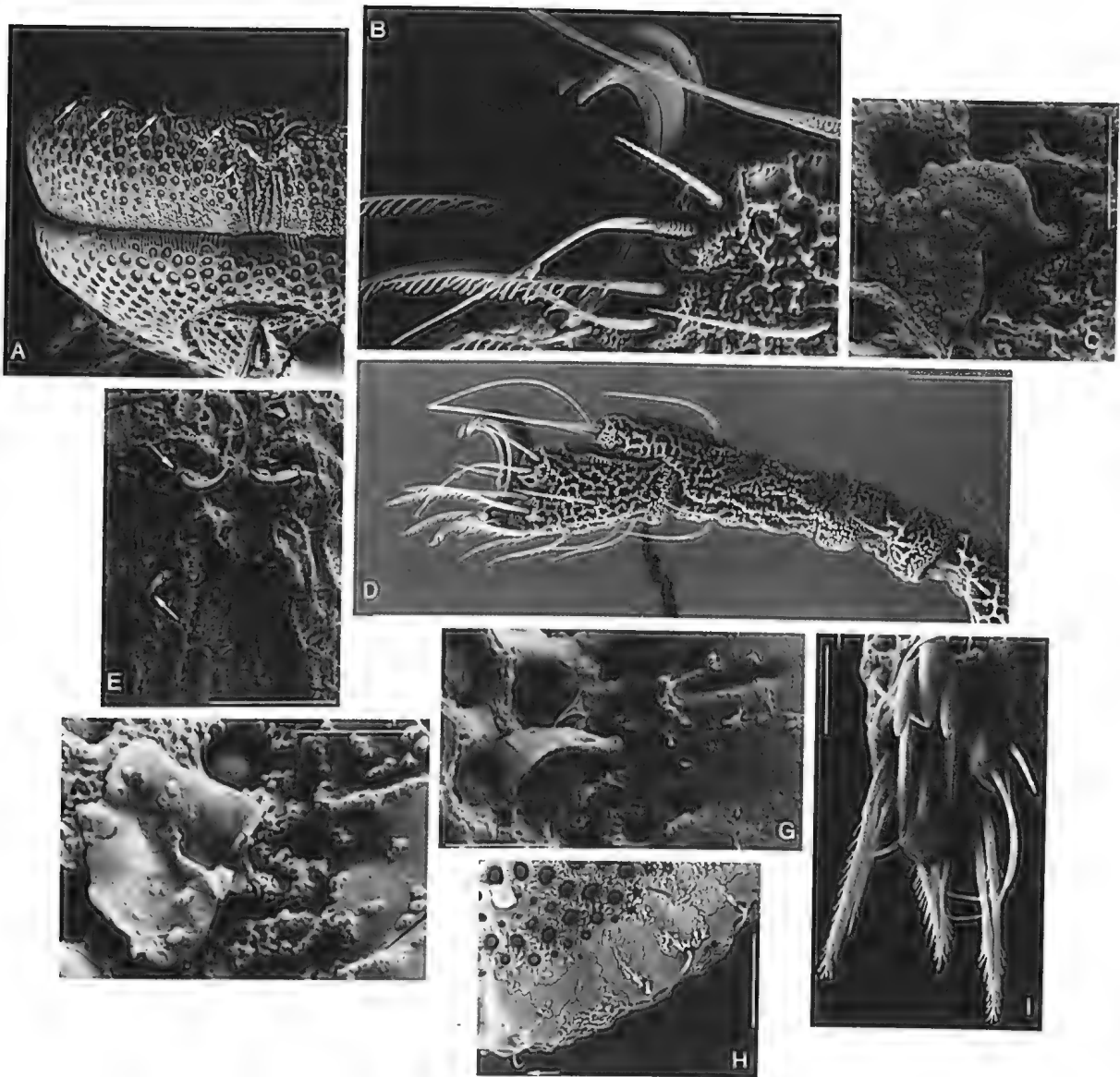


Fig. 5. *Hexachaetoniella contigua* n.sp. A, body, posterior; arrows right to left label setae *p1*, *h1*, *lp*, *p2*, *p3* (*lm* not shown); B, leg I tarsus, distal part, antiaxial; C, F, G, seta *im* mesad of fissura *ia*; D, leg I, distal segments, antiaxial; E, notogastral setae *h1* and *p1*, posterior; H, notogaster, posterior, dorsal, arrows left to right label alveolus of seta *h1* (seta broken), *p1*, *lp*, *p2*, *p3* (*lm* not shown). H. Leg I, tarsus, dorsodistal view. Scale bars: A = 100  $\mu$ m; E, D, H = 50  $\mu$ m; B, C, G, I = 20  $\mu$ m. A, F, G = Otway Ranges; B, E, H = Big Sassy Creek; C = Cradle Mountain.

**Material Examined.** Tasmania: ANIC, Mount Michael, 41°10'S 148°00'E, pyrethrum knockdown from tree, R. Coy, 28 November 1989, 9 adults; AM KS43749, same data, 4 adults; AM KS46584 SEM stub no. S/278 (ill.), same data, 1 adult; ANIC, Cradle Mountain camping ground, 41°35'S 145°55'E, 880 m, pyrethrum knockdown from trees, H. Mitchell, 15 November 1989, 17 adults; AM KS43750, same data, 6 adults; AM KS46585, SEM stub no. S/339 (ill.), same data, 3 adults; AM KS46586 SEM stub no. S/305, Mount Field National Park, ca 42°39'S 146°31'E, L. Masner, 7 January 1984, 3 adults; AM KS46587, SEM stub no. S/306, same data, 3 adults; AM KS43751, same data, 2 adults; CNC, same data, 13 adults; AM KS46588 SEM stub no. S/276, Riveaux River, 43°10'S 146°39'E, Huon pine tree trunk, pyrethrum knockdown, P. Greenslade, 20 December 1988, 1 adult; AM KS46589 SEM stub no. S/307, Lake St Clair National Park, 42°04'S 146°10'E, 750 m, L. Masner, 12 January 1984, 3

adults; CNC, same data, 3 adults; AM KS46590 SEM stub no. S/327-01, Pirates Road, Tasman Peninsula S. track, ca 43°03'S 147°54'E, P. Greenslade and J. Diggle, 16 March 1989, 2 adults; ANIC, Mount Michael, 41°10'S 148°00'E, in moss, A. Trumbull-Ward, 11 June 1990, 1 adult; ANIC, Mount Victoria, 41°20'S 147°49'E, 900 m, pyrethrum knockdown from trees, H. Mitchell and R. Coy, 25 November 1989, 9 adults; CNC, Pedder Lake, 42°55'S 146°05'E, *Asplenium* ferns in laurel forest, L. Masner, 14 January 1984, 1 adult; ANIC, Savage River pipeline, 32 km N. of Savage River mine, myrtle site 2, pyrethrum knockdown, J. Diggle, 19 April 1989, 1 adult.

Victoria: AM KS46591, SEM stub no. S/237 (ill.), Turtons Pass, Otway Ranges, ca 38°33'S 146°15'E, on *Olearia agrophylla* (Musk Daisy), V. Barnes, 16 March 1993, 1 adult; AM KS46592, SEM stub no. S/235, Lilly Pilly Gully,



Wilson's Promontory, ca 39°00'S 147°20'E, on *Olearia agrophylla*, 22 March 1993, V. Barnes, 1 adult; AM KS46593 SEM stub no. S/238, Phillips Track, Young Creek crossing 0.5 km N. of Triplet Falls, Otway Ranges, 38°40'S 143°29'E, moss from *Nothofagus cunninghami*, G. Milledge, P. Lillywhite, C. McPhee and B. Van Praagh, 1 adult.

**Diagnosis.** Notogastral length:width ratio between 1.1:1 and 1.2:1; foveae missing from dorsum of notogaster just inside lateral and posterior margins but extending to anterior margin, most central foveae separated by less than their diameter; posterior notogastral setae *h1* strongly incurved; setae *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* situated at similar level around posterolateral margin.

### Description

**ADULT:** *Body:* brown, sensillus black; length of 2 specimens from type locality 690 µm, 740 µm. *Cerotegument:* crests of reticulations on prodorsum and notogaster with somewhat irregular cushions of cerotegument, foveae with scattered granules of cerotegument on the central plug (Fig. 3F). Setae *ro* and *le* without conspicuous cerotegument (Fig. 3C). Legs with reticulate cerotegument reflecting integument. *Prodorsum:* integument largely foveate-reticulate, most foveae with central plug, carinae between bothridia. *le* situated near front of rostrum; distance between them about 0.70 distance between *ro*, *ro* ventrolateral, weak carina between *le* and *ro*. Pedotectal tooth gradually curving to blunt point. Prodorsum with transverse groove just anterior to transverse furrow. Bothridium close to dorsosejugal suture, directed dorsolaterad, rim subcircular but irregular; posterolateral carina very weak; sensillus club-shaped, its head lying just above bothridial rim (Fig. 3G). *in* small, set just inside edge of dorsosejugal furrow (Fig. 4G), spiniform. *Exuvial scalps:* seen loosely held on some specimens (Fig. 3D). *Notogaster:* oval, length:width 475:410, 540:460. Central region of dorsum foveate but foveae also extending to anterior margin of notogaster, separation between foveae less than their diameter, number of foveae along mid-line 20–28 (mean = 23.3, *n* = 9), along maximum width 18–23 (mean 19), foveae with central plug (Fig. 3F), lateral and posterior marginal areas without foveae; flanks foveate, foveae with central plug (Fig. 5A). Posterior margin centrally not invaginate or with small notch when viewed dorsally, with depression between *p1* when viewed posteriorly. Fissura *ia* and *ip* oblique; *im* perpendicular to sagittal plane. 6 pairs of notogastral setae; *h1* close, on either side of small notch if present, short and strongly incurved (Fig. 5A,E), located at posterior margin; *p1* inserted mid-height on posterior flank, similar spacing to *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* short, arise serially along posterolateral margin (Fig. 5H), their insertions just seen dorsally, *lp<sub>x</sub>* and *p2<sub>x</sub>* inserted posterior to *ip*, *p3<sub>x</sub>* lateral to it, *lm* located just mesad to fissura *im*, with a short, stout base expanding into a flat leaf-like structure (Fig. 5C,F,G), though this is usually broken off so that its base or the alveolus is seen. *Gnathosoma:* pedipalp tarsus with setae (*vt*) with short barbs, *cm* very short barbs, and *l''* smooth; apophysis

supporting seta *acm* long, >0.5 length of its seta; solenidion omega reaching to base of *acm* (Fig. 4E,F). Rutella basally with weak concave flexure and moderate buttressing, without pointed mesad process; transverse striations absent (Fig. 4C,E). *Genitoanal region:* separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 4A). Aggenital and adanal areas and anal and genital valves foveate, most foveae with central plug (Fig. 4B,D). Cuticular thickening extending from adjacent to genital valve to near acetabulum of leg IV (Fig. 4A). Genital setae in straight file (Fig. 4B), all removed a short distance from mesal suture, *g1* long and overlapping, inserted near inner anterior corner of valve; *g5* situated at about 0.5 valve length, *g7* inserted near inner posterior corner; setae *ag* inserted posterior to genital valves, level with anterior margin of anal valves (Fig. 4D), setae *ad1* inserted just anterior to posterior margin of anal valves, *ad2* at or just posterior to posterolateral corner of anal valve, *ad3* conspicuously most laterad of adanal setae, its level between proximal 0.4–0.5 of anal valve (Fig. 4D). *Legs.* Similar to *H. dispersa* (Fig. 5B,D,I).

**Comments.** Body lengths in selected specimens by locality are: Otway Ranges 740 µm, 750 µm; Lilly Pilly Gully 710; Lake St Clair National Park 690 µm; Hellyer Gorge 700; Mount Field National Park 740 µm; Mount Michael 690 µm; Riveaux River 740 µm; Tasman Peninsula 700 µm. The variation in the size and shape of seta *lm* (Fig. 5C,F,G) is not understood, but is treated here as infraspecific.

Although there appears to be a discontinuity between this species and *H. dispersa*, these species may prove to be conspecific, lying at the ends of a range of clinal variation. Biochemical analysis may be useful in resolving this. An extensive north-south range occurs in the arboreal species *Adhaesozetes polyphyllos* Walter & Behan-Pelletier, although this species also is defined on morphological characters (Walter & Behan-Pelletier, 1993).

**Etymology.** The specific epithet refers to the close spacing of notogastral foveae.

**Distribution.** Southern Victoria and Tasmania.

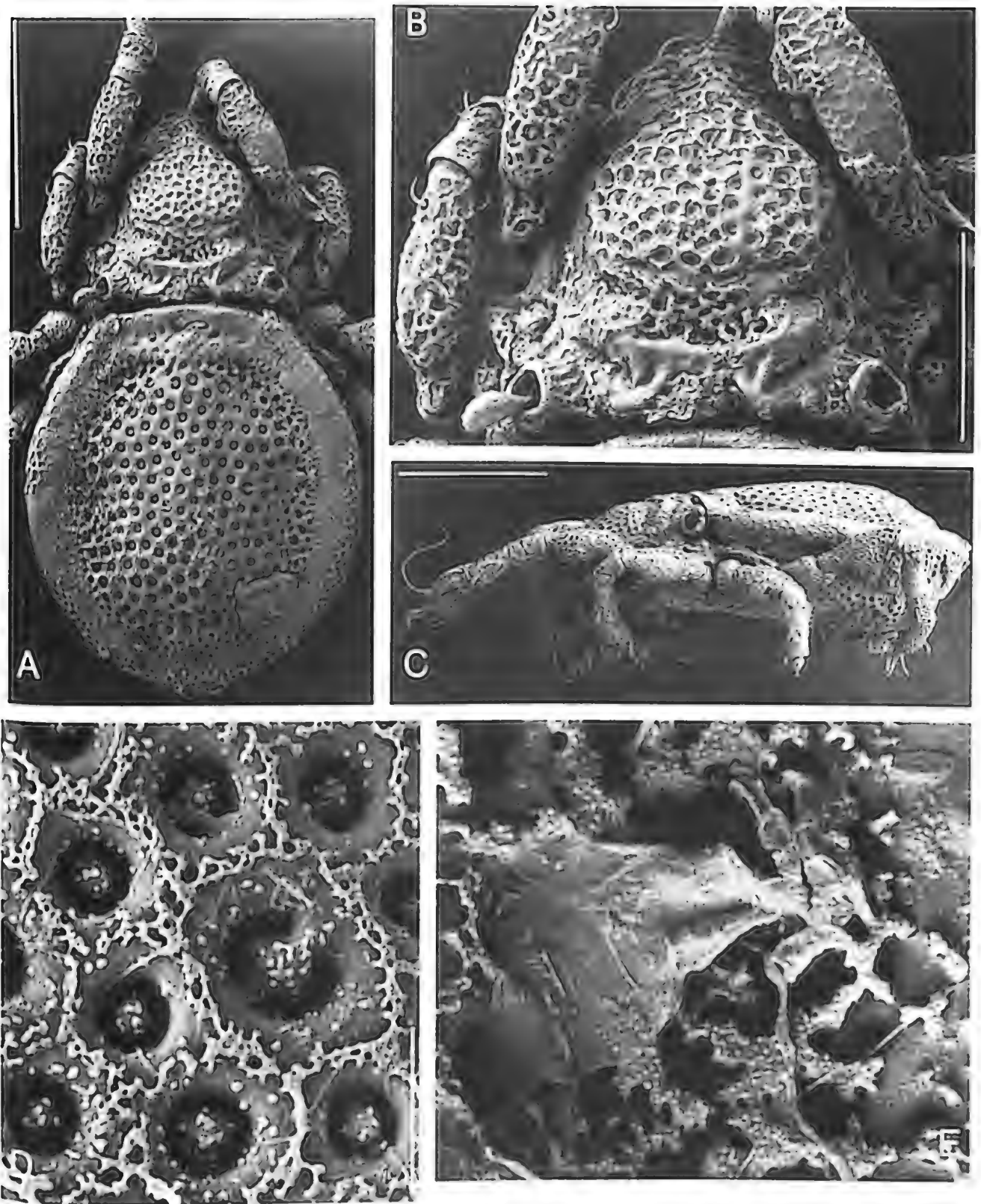
### *Hexachaetoniella dispersa* (P. Balogh), n.comb.

Figs 6, 7

*Pedrocortesella dispersa* P. Balogh, 1985: 55, fig. 4.

**Type material.** Queensland: HOLOTYPE adult. ANIC, Bulburin State Forest, 600 m, subtropical rainforest, leaf litter, G.B. Monteith.

**Material Examined.** New South Wales: AM KS46574 SEM stub no. S/302, Macquarie Pass, 8 km E. of Robertson, 800 m, 34°35'S 150°38'E, laurel-sassafras rainforest, ferns, L. Masner, 8 February 1984, 1 adult; CNC, same data, 2 adults;



**Fig. 6.** *Hexachaetoniella dispersa* (P. Balogh). A, body, dorsal; B, prodorsum, dorsal; C, body, lateral; D, notogastral integument (N.B., one fovea shows central plug connected to surrounding integument); E, seta *im* (N.B., cerotegument deposits across its margin). Scale bars: A,C = 200  $\mu$ m; B = 100  $\mu$ m; D,E = 20  $\mu$ m.

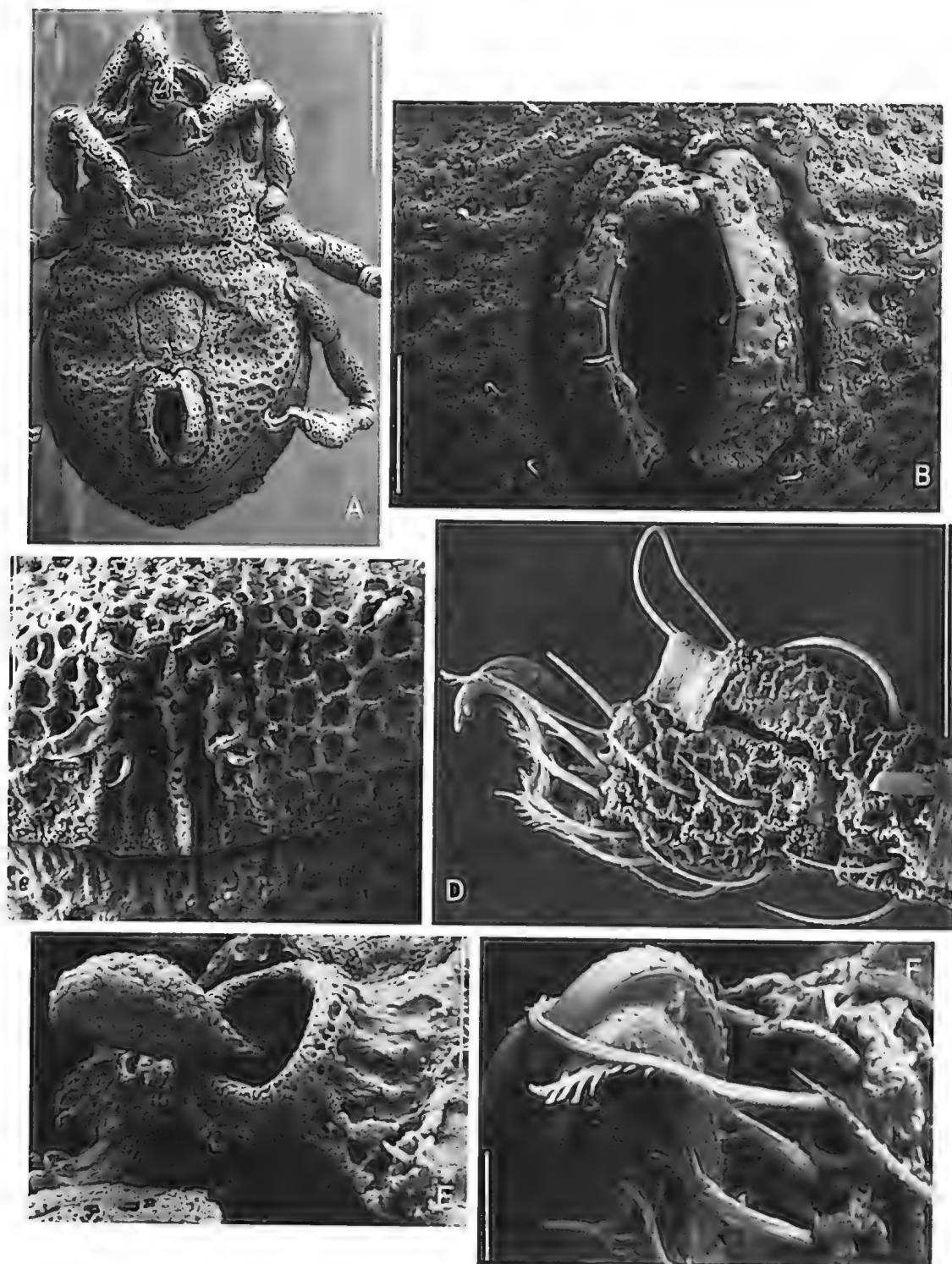


Fig. 7. *Hexachaetoniella dispersa* (P. Balogh). A, body, ventral; B, anal valves; C, notogastral setae *hl*, *pl* and *lp*, posterior view; D, leg I tibia (distal) and tarsus, antiaxial; E, bothridium, sensillus and seta *in*, dorsal; F, leg I tarsus, subdistal. Scale bars: A = 200  $\mu$ m; B,C,D = 50  $\mu$ m; E = 20  $\mu$ m; F = 10  $\mu$ m.

AM KS46575 SEM stub no. S/304, New England National Park, 30°29'S 152°25'E, 1600 m, *Nothofagus moorei* forest, ferns, L. Masner, 12 February 1984, 3 adults; CNC, same data, 5 adults; AM KS46576 SEM stub no. S/309, New England National Park, 30°29'S 152°25'E, 1300–1500 m, *Eucalyptus* wet forest, ferns along creek, L. Masner, 13 February 1984, 1 adult; CNC, same data, 1 adult; CNC, Brown

Mountain, 50 km W. of Bega, 36°36'S 149°23'E, 1100 m, L. Masner, 28 January 1984, 1 adult; ANIC, 2 km N.W. of Bomaderry, 34°51'S 150°35'E, rainforest litter, ANIC berlesate 820, R.J. Moran, 27 February 1983, 1 adult.

Queensland: AM KS46577 SEM stub no. S/308, Landsborough Shire, ca 26°48'S 152°58'E, 200 m, wet sclerophyll *Eucalyptus*

forest, L. Masner, 8 March 1984, 1 adult; CNC, same data, 1 adult; AM KS46578 SEM stub no. S/319, Lamington, 28°15'S 152°58'E, subtropical rainforest canopy, D.E. Walter, early 1994, 4 adults; AM KS46579 SEM stub no. S/101, Mount Bithongabel, Lamington National Park, 28°16'S 153°10'E, *Nothofagus* forest, berlese extraction bark and moss from tree trunks and logs, G.S. Hunt, 14 July 1992, 1 adult; AM KS46580, SEM stub no. S/288 (ill.), Bulburin State Forest, via Builyan, 24°34'S 151°29'E, dry sclerophyll, berlesate bark scraped from trunks & litter, G.S. Hunt, 6 July 1993, 1 adult.

**Rediagnosis.** Notogastral length:width ratio between 1.1:1 and 1.2:1; foveae missing from dorsum of notogaster just inside margins, including anterior margin, most central foveae separated by more than their diameter; posterior notogastral setae *h1* strongly incurved; setae *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* situated at similar level around posterolateral margin.

### Redescription

**ADULT:** *Body:* brown, sensillus black; length of 2 specimens from type locality 590 µm, 630 µm. *Cerotegument:* crests of reticulations on prodorsum and notogaster and rim of bothridium with stellate tubercles of cerotegument which coalesce giving a "stitched" appearance (Fig. 6D); foveae with scattered granules of cerotegument on the central plug (Fig. 6D). Setae *ro* and *le* without conspicuous cerotegument (Fig. 6B). Legs with reticulate cerotegument reflecting integument. *Prodorsum:* integument largely foveate, with carinae between bothridia. *le* situated near front of rostrum; distance between them about 0.70 distance between *ro*, not arising from large pit, *ro* ventrolateral, weak carina between *le* and *ro*. Pedotectal tooth gradually curving to blunt point. Prodorsum with transverse groove just anterior to transverse furrow. Bothridium close to dorsosejugal suture, directed dorsolaterad, rim subcircular but irregular; posterolateral carina very weak; sensillus club-shaped, its head lying just above bothridial rim (Fig. 7E). *in* small, set just inside edge of dorsosejugal furrow (Fig. 7E), spiniform. *Exuvial scalps:* none seen. *Notogaster:* oval, length:width 400:350, 400:340. Central region of dorsum foveate, separation between foveae subequal to their diameter, number of foveae along midline 16–20 (mean = 17.7, *n* = 7), along maximum width 17–20 (mean 17.3), foveae with central plug (Fig. 6A,D), peripheral region without foveae; flanks foveate-alveolate, foveae without central plug (Fig. 7C) Posterior margin centrally not invaginate or with small notch when viewed dorsally, depression between setae *p1* when viewed posteriorly. Fissura *ia* and *ip* oblique, *im* perpendicular to sagittal plane. 5 pairs of small notogastral setae; *h1* close, on either side of small notch if present, strongly incurved (Fig. 7C), located at posterior margin; *p1* inserted low on posterior flank, similar spacing to *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* arise serially along posterolateral margin, their insertions just seen from above, *lp<sub>x</sub>* and *p2<sub>x</sub>* inserted posterior to *ip*, *p3<sub>x</sub>* lateral to it; seta *lm* located just mesad to fissura *im*, with a short, stout base expanding into a flat leaf-like structure (Fig. 6E), though this is usually broken off so that its base or the alveolus

is seen. *Gnathosoma:* pedipalp not studied. *Genitoanal region:* separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 7A). Ventral plate and genital and anal valves foveate, many foveae with central plugs. Cuticular thickening extending from adjacent to genital valve to near acetabulum of leg IV. Genital setae in straight file, all removed a short distance from mesal suture, *g1* long and overlapping, inserted near inner anterior corner of valve; *g5* situated at about 0.5 valve length, *g7* inserted near inner posterior corner; setae *ag* inserted posterior to genital valves, level with anterior margin of anal valves (Fig. 7B), setae *ad1* inserted just anterior to posterior margin of anal valves, *ad2* at or just posterior to posterolateral corner of anal valve, *ad3* conspicuously most laterad of adanal setae, its level between proximal 0.3–0.4 of anal valve. *Legs.* Tibial apophysis overrides about 0.7 tarsus length (Fig. 7D). Distal compression extreme with *ft*", solenidia, alveolus of famulus, *tc*", *it*" and *u*" arranged vertically beneath one another; tarsal cluster placed distally and directed distad on short apophysis, directly above seta *tc*" and antiaxial to retracted claw complex; *ft*" not enclosed in common rim with *omega 1* and 2 but separated by a narrow partition (Fig. 7F); *omega 1* and 2 very close, much longer than *ft*"; tarsus lacking distal recess for receiving retracted unguinal complex, stalk short.

**Variation.** Body length measures for single specimens by locality are: Landsborough Shire 590 µm; Lamington National Park 670 µm; New England National Park 750 µm; Macquarie Pass 710 µm.

**Distribution.** Coastal forests of New South Wales and southern Queensland.

### *Hexachaetoniella norfolkensis* n.sp.

Figs 8, 9

**Type material.** Norfolk Island: HOLOTYPE adult. AM KS46594, SEM stub no. S/115 (ill.) (specimen mounted on side) Palm Glen Track, Norfolk Island National Park, 29°01'S 167°57'E, litter under palms and tree ferns, ANIC berlesate 1027, T.A. Weir, 16 November 1984. PARATYPE adults. AM KS46594 SEM stub no. S/115 (ill.) (with holotype, dorsally and ventrally mounted specimens), same data, 2 adults.

**Diagnosis.** Notogaster weakly convex with an intramarginal depression; notogastral length:width ratio about 1.4:1; foveae present on dorsum of notogaster just inside lateral, posterior margins and anterior margins, most central foveae separated by less than their diameter; posterior notogastral setae *h1* strongly incurved; setae *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* situated at similar level around posterolateral margin.

### Description

**ADULT:** *Body:* brown, sensillus black; length 670 µm. *Cerotegument:* reticulations on prodorsum and notogaster with numerous small granules of cerotegument which



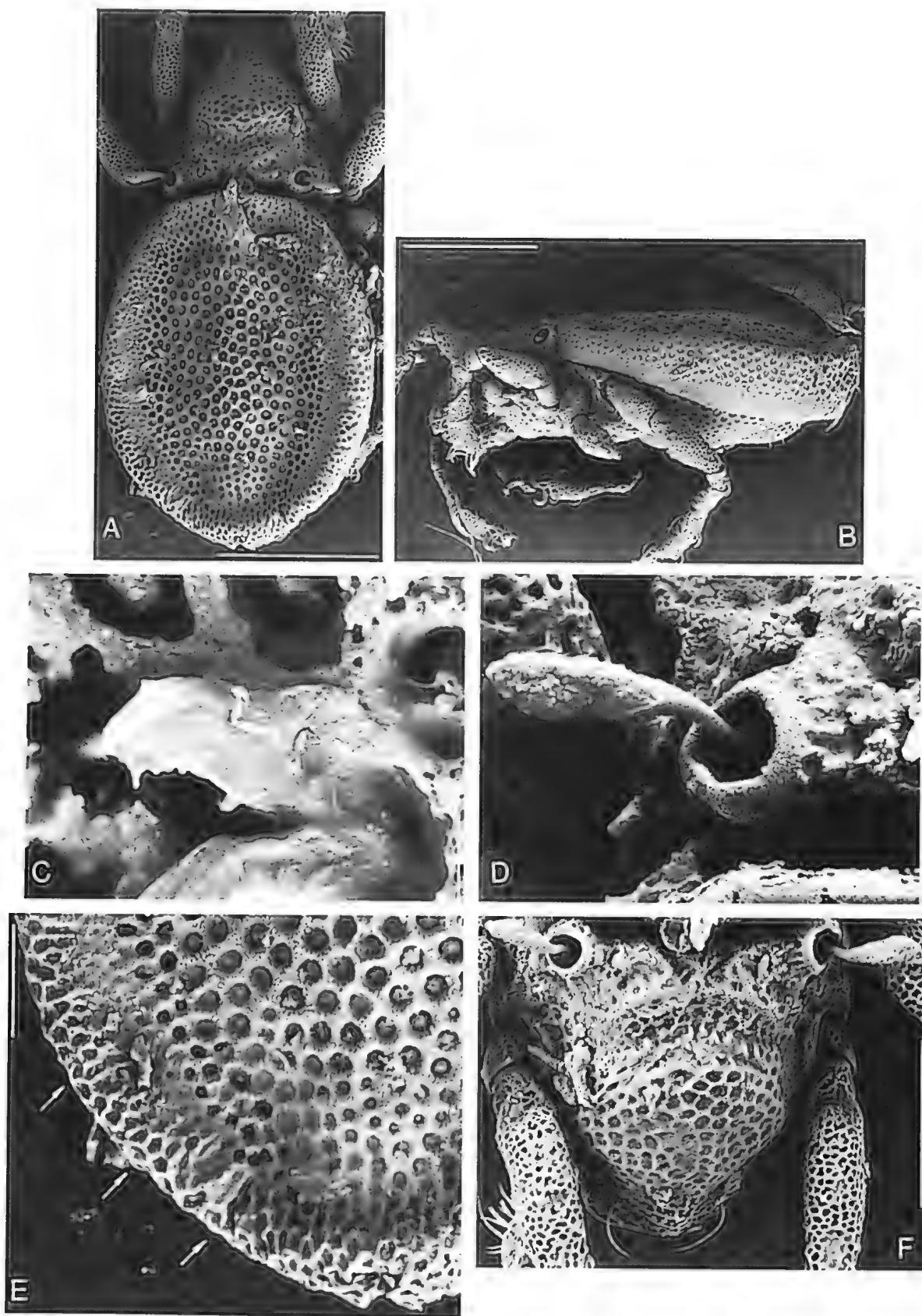


Fig. 8. *Hexachaetoniella norfolkensis* n.sp. A, body, dorsal; B, body, lateral; C, seta *im*; D, bothridium, sensillus and seta *in*, dorsal; E, part of posterior of notogaster, dorsal, arrows right to left label setae *lp*, *p2*, *p3*; F, prodorsum, frontal. Scale bars: A,B = 200  $\mu$ m; F = 100  $\mu$ m; E = 50  $\mu$ m; C = 20  $\mu$ m; D = 10  $\mu$ m.

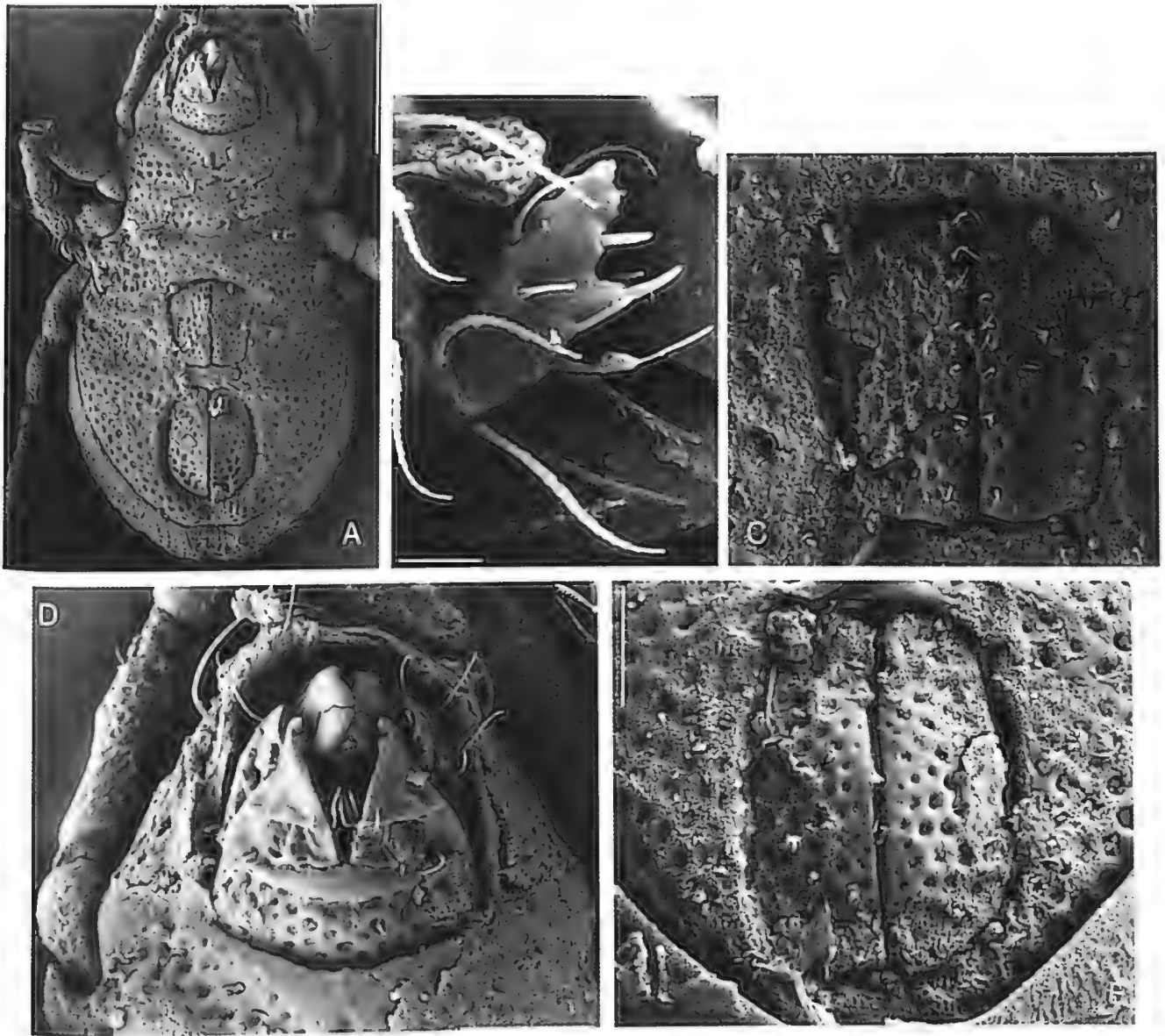


Fig. 9. *Hexachaetoniella norfolkensis* n.sp. A, body, ventral; B, pedipalp, antiaxial; C, genital valves; D, subcapitulum; E, anal valves. Scale bars: A = 100  $\mu$ m; C,D,E = 50  $\mu$ m; B = 10  $\mu$ m.

may coalesce into crests (Fig. 8C,E). Setae *ro* and *le* without conspicuous cerotegument (Fig. 8F). Legs with reticulate cerotegument reflecting integument. *Prodorsum*: integument largely foveate, with carinae between bothridia. *le* situated near front of rostrum; distance between them about 0.70 distance between *ro*, *ro* ventrolateral, no carina between *le* and *ro*. Pedotectal tooth gradually curving to point. Bothridium close to dorsosejugal suture, directed dorsolaterad, rim subcircular; posterolateral carina very weak; sensillus club-shaped, its head relatively elongate compared to *H. dispersa*, starting conspicuously above bothridial rim (Fig. 8D). *in* small, set just inside edge of dorsosejugal furrow (Fig. 8D), spiniform. *Exuvial scalps*: none seen. *Notogaster*: oval but relatively more elongate than *H. dispersa*, length:width 490:350; lower in profile than *H. dispersa*. Central region of dorsum strongly foveate, foveae with central plug, separation of foveae less than their diameter

(Fig. 8A,E), number of foveae along mid-line 24, along maximum width 18; margins also tending to be foveate, much more so than *H. dispersa*; flanks foveate, foveae with central plug (Fig. 8B). Posterior margin with small mesal notch when viewed dorsally, with depression between setae *p1* when viewed posteriorly. Fissura *ia* and *ip* oblique, *im* perpendicular to sagittal plane. Six pairs of notogastral setae; *h1* close, on either side of small notch, short and strongly incurved; *p1* inserted low on posterior flank, similar spacing to *h1*; *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* short, arise serially along posterolateral margin, their insertions just seen dorsally (Fig. 8E, arrows), *lp<sub>x</sub>* closest to fissura *ip*, *lm* located just mesad to fissura *im*, with a short, stout base expanding into a flat leaf-like structure (Fig. 6C). *Gnathosoma*: pedipalp tarsus with setae *vt'* with short barbs, *vt''*, *cm* and *l''* apparently smooth; apophysis supporting seta *acm* long, about 0.5 length of its seta; solenidion omega reaching beyond

base of *acm* (Fig. 9B). Rutella basally with weak concave flexure and moderate buttressing, without pointed mesad process; transverse striations absent (Fig. 9D). *Genitoanal region*: separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture, wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 9A). Aggenital and adanal areas foveate, most foveae with central plug, anal and genital valves with smaller foveae without plug. Weak cuticular thickening extending from adjacent to genital valve to near acetabulum of leg IV. Genital setae in straight file (Fig. 9C), all removed a short distance from mesal suture, *g1* subequal to other setae, inserted near inner anterior corner of valve; *g5* situated at about 0.5 valve length, *g7* inserted near inner posterior corner; setae *ag* inserted posterior to genital valves, level with anterior margin of anal valves (Fig. 9E), setae *ad1* inserted just anterior to posterior margin of anal valves, *ad2* at or just posterior to posterolateral corner of anal valve, *ad3* conspicuously most laterad of adanal setae, its level between proximal 0.4–0.5 of anal valve (Fig. 7E). *Legs*. Similar to *H. dispersa*.

**Etymology.** The specific epithet refers to Norfolk Island.

**Distribution.** Norfolk Island.

### General Discussion

In comparison with *Pedrocortesella*, this is a small genus which appears to have become specialised for a largely arboreal way of life. Possible arboreal adaptations include the short ovoid sensillus, the long solenidia on tarsus I and the long ventrally directed barbs on the terminal tarsal setae. The type species from New Zealand, *H. sexpilosa*, has a more elongate sensillus and may not be as adapted as the Australian species for arboreal life.

The genus shares with *Labiogena* an elongate apophysis supporting seta *acm* on the pedipalp tarsus (Hunt, 1996b). This suggests a possible relationship between these taxa. Both appear to have evolved from the *Pedrocortesella* lineage which resembles them in possessing a depressed notogaster.

The type species of *Lyrifissella* Paschoal, *L. latoclava* Hammer, also from New Zealand, appears to have a raised central mound in each fovea, and setae *ag* are posterior to the genital valves, two characters in common with *Hexachaetoniella*. This suggests a closer relationship between these genera than their placement in separate families proposed by Paschoal (1989a; 1989b).

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## Description of Predominantly Arboreal Plateremaeoid Mites from Eastern Australia (Acarina: Cryptostigmata: Plateremaeoidea)

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**ABSTRACT.** Two new genera of the superfamily Plateremaeoidea, *Labiogena* and *Darthvaderum*, are proposed, and *Novazelandiella* Paschoal rediagnosed. The genera are tentatively assigned to the family Hammeriellidae. Four new species are described from eastern Australian arboreal habitats: *Labiogena convexa* n.sp., *Labiogena walteri* n.sp., *Novazelandiella kellyi* n.sp., and *Darthvaderum greensladeae* n.sp., the type species of *Darthvaderum* n.gen. One new combination is established, *Labiogena queenslandica* (*Pedrocortesella*) (P. Balogh, 1985) and the species is redescribed and designated the type species of *Labiogena* n.gen. Keys are given to the species of *Labiogena*, and to plateremaeoid genera recorded from arboreal habitats in Australia.

HUNT, GLENN S., 1996. Description of predominantly arboreal plateremaeoid mites from eastern Australia (Acarina: Cryptostigmata: Plateremaeoidea). Records of the Australian Museum 48: 303–324.

Oribatid mites have traditionally been regarded as inhabitants of the soil or ground litter but more recently have been recognised as an important component of the acarine fauna of forest canopies (for example, Walter, 1995). The predominantly arboreal genus *Hexachaetoniella* (family *Pedrocortesellidae*) and some arboreal *Pedrocortesella* species have been reviewed elsewhere (Hunt 1996a;b). The present paper includes descriptions of further arboreal species from eastern Australia which are tentatively assigned to the Hammeriellidae.

Arboreal species typically have a sensillus which terminates in an ovoid or spherical head (Hunt, 1996b) whereas species living on the forest floor usually have a sensillus of more elongate form. Some of the latter species have, however, been recorded

from tree trunks and their genera are included in the key below (couplets 2 and 3).

### Methods

Descriptions apply to adults only. A Cambridge Stereoscan 120 with Robinson Detector was used for Scanning Electron Microscopy (SEM). The following abbreviations are used to indicate the present location of material: AM—Australian Museum, Sydney; ANIC—Australian National Insect Collection, Canberra; CNC—Canadian National Collections of Insects, Arachnids and Nematodes, Ottawa; FMNH—Field Museum of Natural History, Chicago; QM—Queensland Museum, Brisbane.

Specimens are preserved in alcohol unless otherwise stated.

Many structures referred to in descriptions and the key are illustrated with their abbreviations in Hunt (1996a, fig. 1) and Fig. 1 below. Measurements are in micrometers and ratios of notogaster length to width in

descriptions are given in the actual measures, e.g., 540:460, for each specimen measured. The abbreviation "ill." means the SEM was used to illustrate the species in descriptions.

Many characters of systematic value are analysed and illustrated by Hunt (1996a,b).

### Key to plateremaeoid genera represented in Australian arboreal habitats

- 1 Prodorsum with enantiophyses (opposing horns) present on transverse furrow ..... 2
- Prodorsum without enantiophyses (Fig. 5B) ..... 3
- 2 Prodorsum foveate or without pits ..... *Pheroliodes* Grandjean
- Prodorsum alveolate-reticulate; sensillus with short, twisted petiole ..... *Octoliodes* Paschoal
- 3 Sensillus terminating in a flattened blade ..... *Pedrocortesella* Hammer
- Sensillus terminating in an ovoid or spherical club (Fig. 5E) ..... 4
- 4 Anal valves with 3 pairs of setae; ..... 5
- Anal valves with 2 pairs of setae ..... 6
- 5 Notogaster dorsally with complete oval groove or depression inside its margin; shape of groove closely parallels margins of notogaster (Fig. 12A) ..... *Darthvaderum* Hunt
- Notogaster dorsally without complete oval groove or depression inside its margin, groove interrupted posteriorly; shape of groove does not closely parallel lateral margins notogaster ..... *Pedrocortesella* *enigma* Hunt
- 6 Notogaster with a seta (seta *lm*) or its alveolus immediately mesad of fissura *im*; each fovea on notogaster with central mound (appears darker under transmitted light) ..... *Hexachaetoniella* Paschoal
- Notogaster without a seta or its alveolus immediately mesad of fissura *im*; foveae if present without central mound (Fig. 5C) ..... 7
- 7 Head of sensillus entirely above rim of bothridium (Fig. 5E) ..... 8
- Head of sensillus at least partly contained within rim of bothridium (Fig. 10C,E) ..... *Novazelandiella* Paschoal
- 8 In dorsal view, marginal zone of notogaster free of foveae (Fig. 5F) ..... *Labiogena* Hunt
- In dorsal view, foveae extend over entire width of notogaster ..... *Pedrocortesella* *nortoni* Hunt

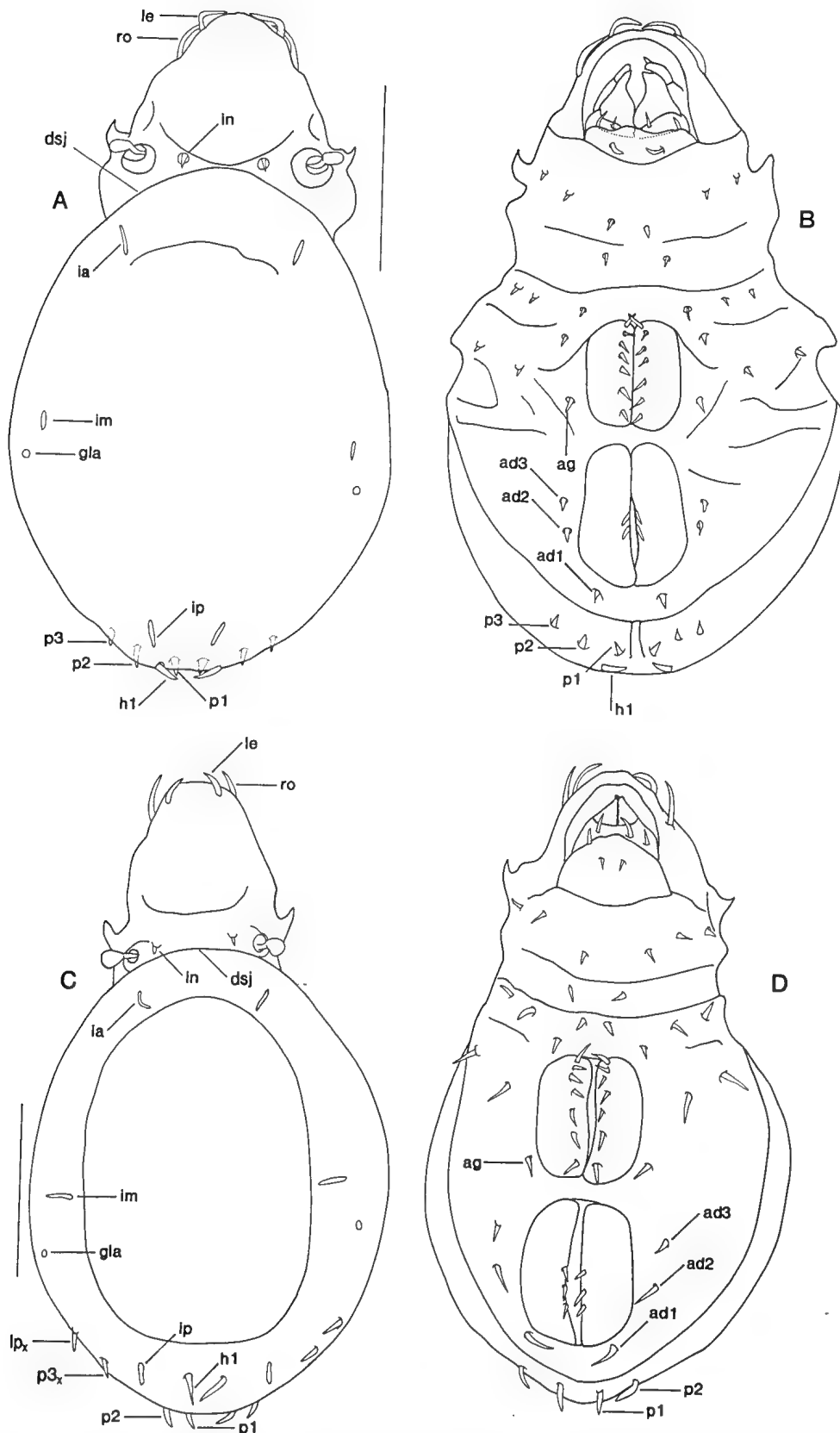


Fig. 1. A,B: *Labiogenes queenslandica* (P. Balogh). A, body, dorsal (scalps removed); B, body, ventral (dashed line shows position of labiogenal suture dorsal to mental tectum). C,D: *Darthvaderum greensladeae* n.sp. C, body, dorsal (scalps removed); D, body, ventral. Scale bars = 200  $\mu$ m. *dsj* = dorsosejugal suture; *ro* = rostral seta; *le* = lamellar seta; *ex* = exobothridial seta; *in* = interlamellar seta; *h1*, *lp*, *p1*, *p2*, *p3* = notogastral setae; *lp<sub>x</sub>*, *p3<sub>x</sub>* = notogastral setae of possible homology with setae *lp* and *p3* in Fig. 1A,B; *ag* = aggenital seta; *ad1*, *ad2*, *ad3* = adanal setae; *ia*, *im*, *ip* = fissurae; *gla* = opening of lateral opisthosomal gland. N.B., integumental microsculpture shown in SEMs.

*Labiogena* n.gen.

**Type species.** *Pedrocortesella queenslandica* P. Balogh, 1985: 56, fig. 5.

**Diagnosis.** Prodorsum with shallow transverse furrow, enantiophyses absent; sensillus a petiolate ovoid club, not a blade; seta *ex* absent; adults may carry exuvial scalps; notogaster usually with marginal zone free from microsculpture; 4–5 pairs of notogastral setae; subcapitulum with mental tectum reaching rutella and obscuring labiogenal suture mesally, rutellum with transverse striations; seta *ag* lateral to genital valves; 2 pairs of anal setae, 3 pairs adanal, *ad3* subequal to *ad2* in distance from anal valves; distal compression of tarsus I extreme, tarsal cluster of leg I oriented distodorsad, terminal setae flattened.

## Description

Plateremaeoid mites of medium size (length about 450–800 µm); body covered with layer of cerotegument, reticular pattern and other high points usually with hemispherical mounds of cerotegument which may coalesce into crests with crusty appearance; notogaster with exuvial scalps, ovate; prodorsum with shallow transverse furrow, no enantiophyses; seta *le* dorsolateral, *ro* ventrolateral; seta *ex* absent; seta *in* small, spinous and arising from apophysis, inserted about equal to or > bothridial diameter from bothridial rim; bothridium with posterolateral carina or carina absent; bothridium abutting dorsosejugal suture or slightly anterior of it, its posterior wall complete, posterolateral carina weak to virtually absent; sensillus short, distal part ovoid (clavate), the head being somewhat granular or fluted in appearance, not supported by a smooth spoon-like extension of sensillus petiole. Anterior margin of notogaster gently convex, forming a slightly angular transition with lateral margins; notogaster broadly convex or very flattened in posterior aspect; integument foveate-reticulate or alveolate-reticulate, foveae without central raised plug, marginal zone usually without foveae or alveoli; notogaster with 4–5 pairs of setae; setae *lp<sub>x</sub>*, *p2<sub>x</sub>* and *p3<sub>x</sub>* situated dorsally at the same general level as *h1* with *lp<sub>x</sub>* if present close to fissura *ip*, or setae *p2* and *p3* at same general level as *p1* situated on posterior flank ventral to *h1*. Subcapitulum with mental tectum reaching rutella and obscuring labiogenal suture mesally; pedipalp tarsus seta *l*" smooth, apophysis supporting eupathidial seta *acm* long. Epimeral chaetotaxy 3:1:3:3; anal and genital plates close; genitoanal chaetotaxy 7:1:2:3; genital setae forming straight line near inner margin of valve, not forming an arc; seta *ag* lateral to genital valves; setae *ad1* just posterior to anal valves, setae *ad3* subequal to setae *ad2* in distance from anal valve. Femoral and trochanteral tracheae present; integument on legs in more or less regular closely spaced reticulate pattern;

distal compression strong, tarsal cluster on leg I directed dorsodistad and slightly proximad to setae (*tc*); opening to cavity enclosing undeveloped famulus not seen; solenidion *omega 1* longer than seta *ft*"; leg tarsi heterotridactylous, laterals weaker than central prong; claw stalk medium or short. *Labiogena queenslandica* and *L. walteri* with iteral setae on all tarsi (absent from leg IV in *L. convexa*).

**Comments.** The absence of a well-developed transverse furrow on the prodorsum, and the presence of iteral setae on the tarsus of leg IV in the type species and *L. walteri*, suggest the genus may be referable to the family Hammeriellidae Paschoal (see General Discussion below). It differs from Paschoal's diagnosis of the family in having two pairs of anal setae, rather than three.

The genus is defined predominantly by gnathosomal characters: a mental tectum extends anteriorly to reach the rutella and under SEM obscures the mesal section of the labiogenal suture; the apophysis supporting seta *acm* of the pedipalp is long; and seta *l*" on the pedipalp is smooth. The genus also possesses a marginal zone on the notogaster devoid of foveae or alveoli.

Of the three species in *Labiogena*, *L. convexa* tends to have the "*Pedrocortesella*" arrangement of notogastral setae described by Hunt (1996a) in which setae *p2* and *p3* lie at the same general level dorsally as setae *h1*. In *L. queenslandica* (P. Balogh) and *L. walteri* n.sp., the notogaster has become flattened and habitually carries scalps (nymphal exuviae), possibly inhibiting migration of setae *p2* and *p3* from their nymphal (presumably primitive) position at the same general level as *p1*. These two species have possibly secondarily derived this primitive "*Pheroliodes*" arrangement of setae (Hunt, 1996a, fig. 1C). Development of seta *lp* has apparently been suppressed in the adult of *L. queenslandica*.

An interesting correspondence with *Labiogena* occurs in the Cymbaeremaeidae where Behan-Pelletier (1988) records both a mental tectum and a large apophysis supporting seta *acm* on the palpal tarsus.

**Etymology.** The Latinised generic name alludes to the modification of the area of the labiogenal suture by a mental tectum. Gender is feminine.

# Key to adults of species in genus *Labiogena*

N.B., for identification under transmitted light the animal should be cleared. Exuvial scalps, if present, should be removed but retained for later examination)

- 1 Distance of seta *in* from bothridium < bothridial diameter (Fig. 2B), notogaster broadly convex (Fig. 2E,F) (more easily seen after scalps removed) ..... *L. convexa* n.sp.
- Distance of seta *in* from bothridium > bothridial diameter (Fig. 5B), notogaster with concave areas (Fig. 5F) (more easily seen after scalps removed) ..... 2
- 2 The most posterior pair of setae on scalps arise on widely spaced apophyses (Fig. 5H); setae *h1* more widely separated than *p1* (Fig. 7A) ..... *L. queenslandica* (P. Balogh), n.comb.
- The most posterior pair of setae on scalps arise from central apophysis; setae *h1* less widely separated than *p1* (Fig. 8F) ..... *L. walteri* n.sp.

## *Labiogena convexa* n.sp.

Figs 2, 3, 4A,B,D

**Type material.** Queensland: HOLOTYPE adult. QM, Bulburin State Forest, via Builyan, 24°34'S 151°29'E, berlesate bark scraped from trunks, rainforest, G.S.Hunt, 6 July 1993. PARATYPE adults. QM, SEM stub no. S/266 (ill.), same data as holotype, 2 adults; AM KS46567, SEM stub no. S/267 (ill.), same data, 1 adult; AM KS43745, same data, 2 adults; ANIC, same data, 1 adult; CNC, same data, 1 adult; QM, same data, 1 adult; QM S20088 SEM stub no. S/047 (ill.), Bulburin State Forest (barracks) via Builyan, 24°32'S 151°34'E, 600 m, rainforest, QM berlesate 826, G.B. Monteith, 16 Sept. 1989, 1 adult.

**Diagnosis.** Body medium, length about 540 µm; scalps with pair of moderately long posterior setae each arising from apophysis; bothridium close to notogaster, *in* set < bothridial diameter from bothridial rim; notogaster convex, foveate-reticulate, surrounded by border free of foveae; 5 pairs notogastral setae, *lp* present, *h1* very widely separated, much more so than *p1*, 2 pairs notogastral setae anterior to fissura *ip*; tarsus of leg IV lacking iter setae.

## Description

**ADULT:** *Body:* brown; length about 540 µm. *Cerotegument:* body generally with thin veneer of cerotegument and fine granules on areas of higher relief like reticulations (Fig. 2C); notogastral setae completely enclosed (Fig. 2E) and leg setae without thick basal accumulations (Fig. 4A,B,D). *Prodorsum:* transverse furrow shallow but distinct (Fig. 2D); integument reticulate-alveolate; weak carina between *le* and *ro*; *le* dorsolateral and situated close to anterior of rostrum,

strongly curved mesad distance between them about 0.7 distance between *ro*, *ro* ventrolateral, insertion not visible from above; pedotectal tooth tapering gradually to blunt tip. Bothridium close to but not leaning on notogaster (Fig. 2B), wall subcircular, posterolateral carina weak; sensillus a fluted ovoid club arising from a smooth petiole just above bothridial rim (Fig. 2B,D). Carina forming posterior rim of transverse furrow with short branches to dorsosejugal suture (Fig. 2B); *in* small on small apophysis cloaked in cerotegument, separated from bothridium by less than bothridial diameter, set just inside edge of dorsosejugal furrow (Fig. 2B). *Exuvial scalps:* with upturned crenellate margins and medium length caudal setae, shorter and closer together than *L. queenslandica*; setae *lp* present on all nymphal scalps (Fig. 2G). *Notogaster:* oval, length:width without scalps 380:320, broadly convex (Fig. 2E), surrounded by border largely free of foveae, remainder foveate-reticulate (Fig. 2F); posterior margin not invaginate when viewed from above, with carina flanked by shallow grooves between setae *p1* when viewed posteriorly (Fig. 2E). Fissura *ia* subparallel-oblique to sagittal plane, *im* perpendicular, *ip* parallel to plane; 5 pairs of short notogastral setae (Fig. 2E), *h1* turned mesad, *p1* at about midheight on posterior flank, *lp*, *p2* and *p3* at same level on posterolateral margin slightly ventral to *h1*. *Gnathosoma:* rutella predominantly concave, moderate transverse striations (Fig. 3B). Pedipalp tarsus with setae (*vt*) with short side branches, *cm* and *l''* smooth; apophysis supporting seta *acm* moderately strong, >0.5 seta length; solenidion reaching beyond base of *acm* (Fig. 3C). *Epimeral region:* weakly convex anterior to genital valves, not tending to overhang them. *Genitoanal region:* separation of anal and genital vestibules relatively broad but with interruption to ventral plate microsculpture (Fig. 3A), Ventral plate reticulate-alveolate, no cuticular thickenings adjacent to genital and anal valves, weak thickenings immediately posterior to leg IV. Genitoanal

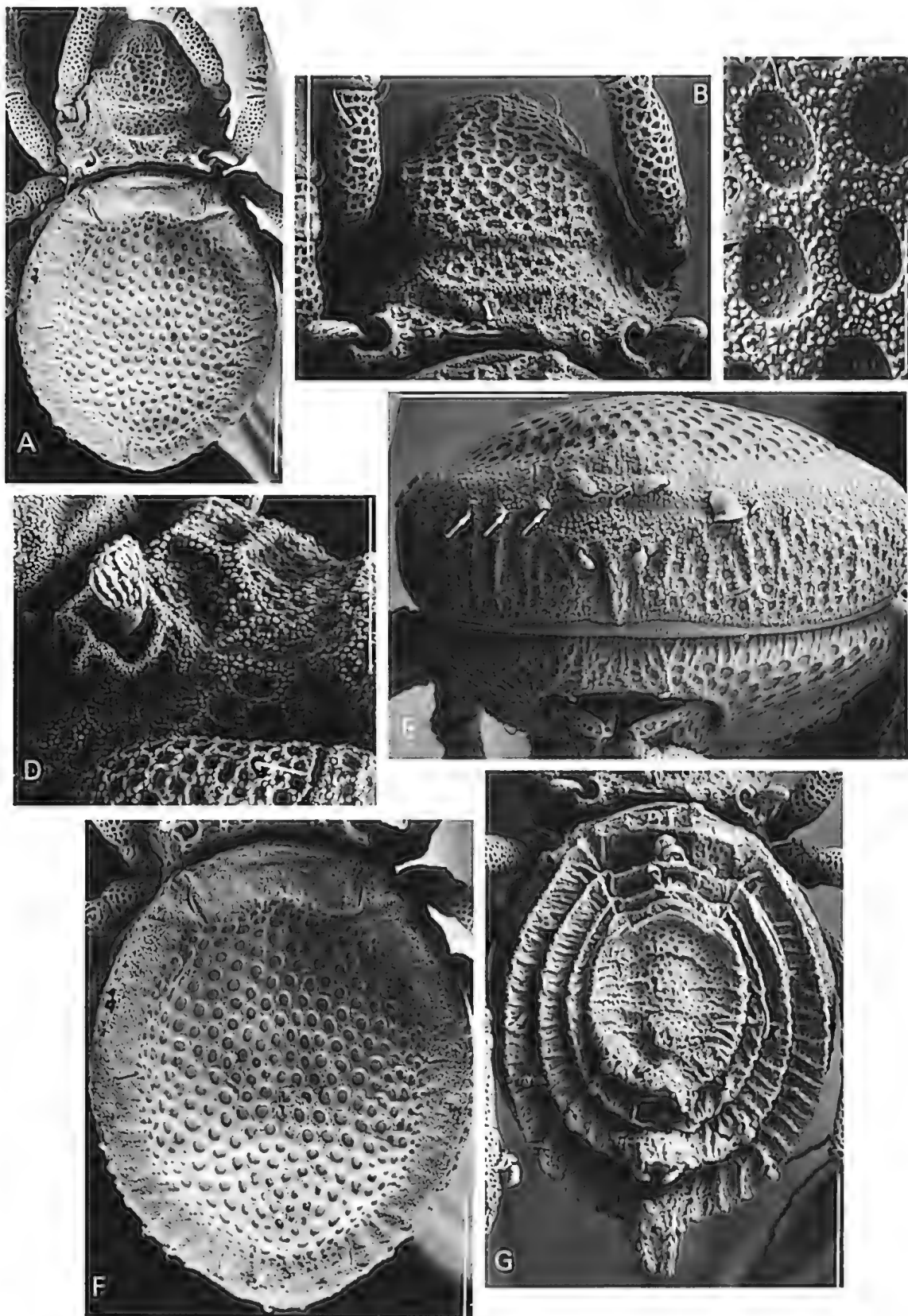
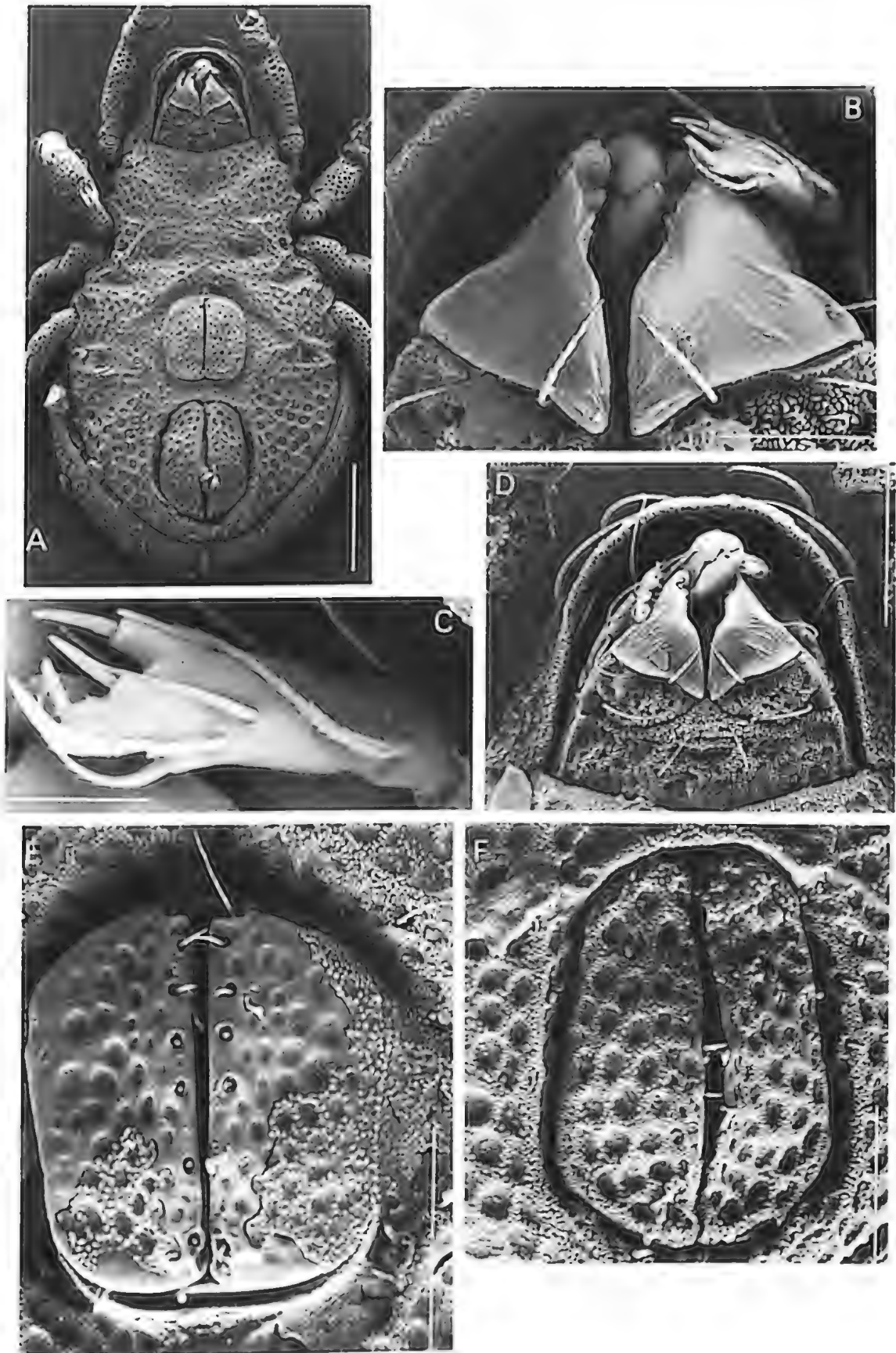


Fig. 2. *Labiogenia convexa* n.sp. A, body, dorsal without exuvial scalps; B, prodorsum, dorsal; C, notogastral integument, detail; D, bothridium and sensillus, dorsolateral; E, body, posterior without scalps, arrows right to left label setae  $lp_x$ ,  $p2_x$  and  $p3_x$ ; F, notogaster, dorsal without scalps, arrows right to left label setae  $p1$ ,  $h1$ ,  $lp_x$ ,  $p2_x$  and  $p3_x$ ; G, exuvial scalps, dorsal. Scale bars: A,B,E–G = 100  $\mu$ m; D = 50  $\mu$ m; C = 20  $\mu$ m.





**Fig. 3.** *Labiogenia convexa* n.sp. A, body, ventral; B, rutella; C, pedipalp tarsus, antiaxial; D, subcapitulum; E, genital valves; F, anal valves. Scale bars: A = 100  $\mu\text{m}$ ; D-F = 50  $\mu\text{m}$ ; B = 20  $\mu\text{m}$ ; C = 10  $\mu\text{m}$ .



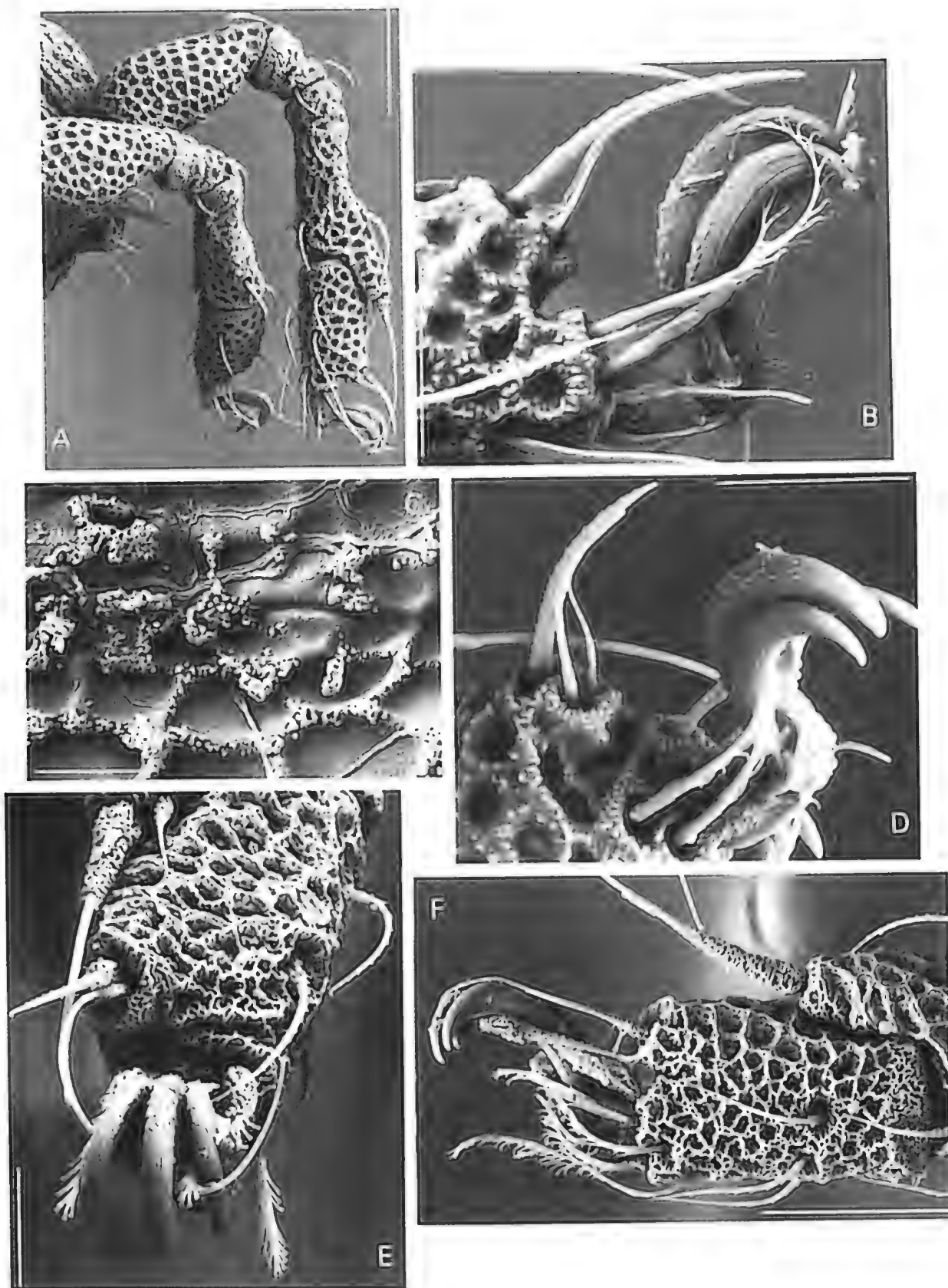


Fig. 4. A,B,D: *Labiogenia convexa* n.sp. A, legs I and II, anti-axial; B,D, leg I tarsus (distal), anti-axial and oblique dorsolateral. C,E,F: *Labiogenia walteri* n.sp. C, notogastral integument and fissura *im*; E,F, leg I tarsus, anti-axial and distodorsal. Scale bars: A,F = 50  $\mu$ m; B-E = 20  $\mu$ m. E,F = Macquarie Pass; C = New England National Park; A,B,D = Bulburin.

chaetotaxy 7:1:2:3; genital seta *gl* long, others short, essentially in straight file (Fig. 3E), *gl* at inner anterior corner in marginal notch, *g5* at about 0.5 valve length; *g7* inserted well anterior to inner posterior corner, not in marginal notch; setae *ag* short, inserted at level between *g6* and *g7*; adanal setae short (Fig. 3F), *ad1* postanal, *ad2* and *ad3* subequal in distance from anal valve. *Legs*. Apophysis of tibia I overrides 0.4 of tarsus (Fig. 4A). Tarsal cluster of leg I placed distodorsally on distinct apophysis but not antiaxial to claw complex (Fig. 4B), partition separating *ft*" from *omega 1* and 2, latter close together (Fig. 4D), *omega 1* shorter than *ft*", alveolus for undeveloped seta *epsilon* not seen; terminal setae elongate and only slightly flattened (Fig. 4B); tarsi I to IV with setae (*it*); tarsus I without distal recess for receiving retracted unguinal complex, stalk medium length; tarsus of leg IV without iterate setae.

**Comments.** The convex notogaster, distribution of notogastral setae, and the absence of iterate setae on the tarsus of leg IV mean this species does not sit easily with *L. queenslandica* and *L. walteri*. It is tentatively placed in *Labiogena* because it possesses a mental tectum, a long apophysis supporting seta *acm* on the pedipalp, and a marginal zone on the notogaster devoid of foveae or alveoli.

**Etymology.** The specific epithet refers to the convex notogaster which contrasts to that in the type species.

**Distribution.** Eastern Queensland: Lamington National Park, near Brisbane, to Cape Tribulation, near Cairns.

### *Labiogena queenslandica* (P. Balogh), n.comb.

Figs 1A,B, 5-7

*Pedrocortesella queenslandica* P. Balogh, 1985: 56, fig. 5.

**Type material.** Queensland: HOLOTYPE adult. ANIC, Bulburin State Forest, 600 m, subtropical rainforest, leaf litter, G.B. Monteith. Examined.

**Other material examined.** New South Wales: AM.KS46562 SEM stub no. S/331 (ill.), Mount Allyn, near Barrington Tops, 32°08'S 151°26'E bark scraped from *Nothofagus*, temperate rainforest, G.S. Hunt, 20 Sept. 1993, 3 adults.

Queensland: AM KS46561, SEM stub no. S/268 (ill.), Bulburin State Forest, via Builgan, 24°34'S 151°29'E, berlesate bark scraped from trunks, rainforest, G.S.Hunt, 6 July 1993, 3 adults; AM KS43744, same data, 1 adult.

**Diagnosis.** Body medium-large, length about 760  $\mu$ m; scalps with pair of very long spatulate posterior setae arising from widely spaced apophyses; bothridium away from notogaster, *in* set > bothridial diameter from bothridial rim; notogaster alveolate-reticulate, surrounded

by foveae free border; 4 pairs notogastral setae, *lp* absent, setae *hl* dorsally on posterior flank, *p1-3* more ventrally at same level to each other; *hl* further apart than *p1*, tarsus of leg IV with iterate setae.

### Description

**ADULT:** *Body:* brownish-green; length about 750  $\mu$ m. *Cerotegument:* body generally with thin veneer of cerotegument and fine granules of cerotegument which coalesce into "crusty" mounds or ridges on areas of higher relief (Fig. 5C,E); notogastral and leg setae with thick basal accumulations, setae *p1*, 2 and 3 with only tips emerging (Fig. 7A). *Prodorsum:* broad; transverse furrow very shallow; integument reticulate-foveate; weak carina between *le* and *ro*; *le* dorsolateral and situated close to anterior of rostrum, strongly curved mesad, distance between them about 0.6 distance between *ro*, *ro* ventrolateral, insertion not visible from above. Pedotectal tooth tapering gradually to blunt tip; bothridium somewhat removed from notogaster but near margin of dorsosejugal suture (Fig. 5B,E), wall subcircular; rim with lateral beak but posterolateral carina absent; sensillus a granulate ovoid club arising from a smooth petiole just above bothridial rim (Fig. 5E); a strong carina sloping obliquely from anterior of bothridium towards midline of posterior margin of prodorsum; *in* small on small apophysis, separated from bothridium by much greater than bothridial diameter, set just inside edge of dorsosejugal furrow, spiniform; base enclosed in cerotegument (Fig. 5E). *Exuvial scalps:* with upturned crenellate margins and long caudal setae directed posterodorsad each arising from its separate apophysis, setae *lp* apparently absent on tritonymphal scalp and adult. *Notogaster:* oval, length:width without scalps 590:480, surrounded by border largely free of foveae, remainder foveate-reticulate or alveolate-reticulate (Fig. 5C,F); posterior margin not invaginate when viewed from above, with vertical carina flanked by grooves between setae *p1* when viewed posteriorly (Figs 1A,B; 7A). Fissura *ia* long, oblique to sagittal plane, *im* short, parallel to plane, *ip* close to midline, subparallel-oblique to plane; 4 pairs of short notogastral setae (Fig. 7A), *hl* turned mesad, *lp* apparently absent, *p2* and *p3* at same level as *p1* on posterior flank. *Gnathosoma:* rutella predominantly concave, weak transverse striations (Fig. 6E). Pedipalp tarsus with setae (*vt*) with short side branches, *cm* branches very short; *l*" smooth; apophysis supporting seta *acm* very long, > seta length; solenidion very long reaching beyond base of *acm* (Fig. 6F). *Epimeral region:* strongly convex anterior to genital valves, but not tending to overhang them. *Genitoanal region:* separation of anal and genital vestibules relatively narrow with interruption to ventral plate microsculpture, moderately wide mesal isthmus without strong transverse grooves between the vestibules (Fig. 6A). Ventral plate reticulate-foveate, cuticular thickenings adjacent to both genital and anal valves, and immediately posterior to leg IV (Fig. 6A). Genitoanal chaetotaxy 7:1:2:3; genital setae long, essentially in straight file (Fig. 6B), *gl* at

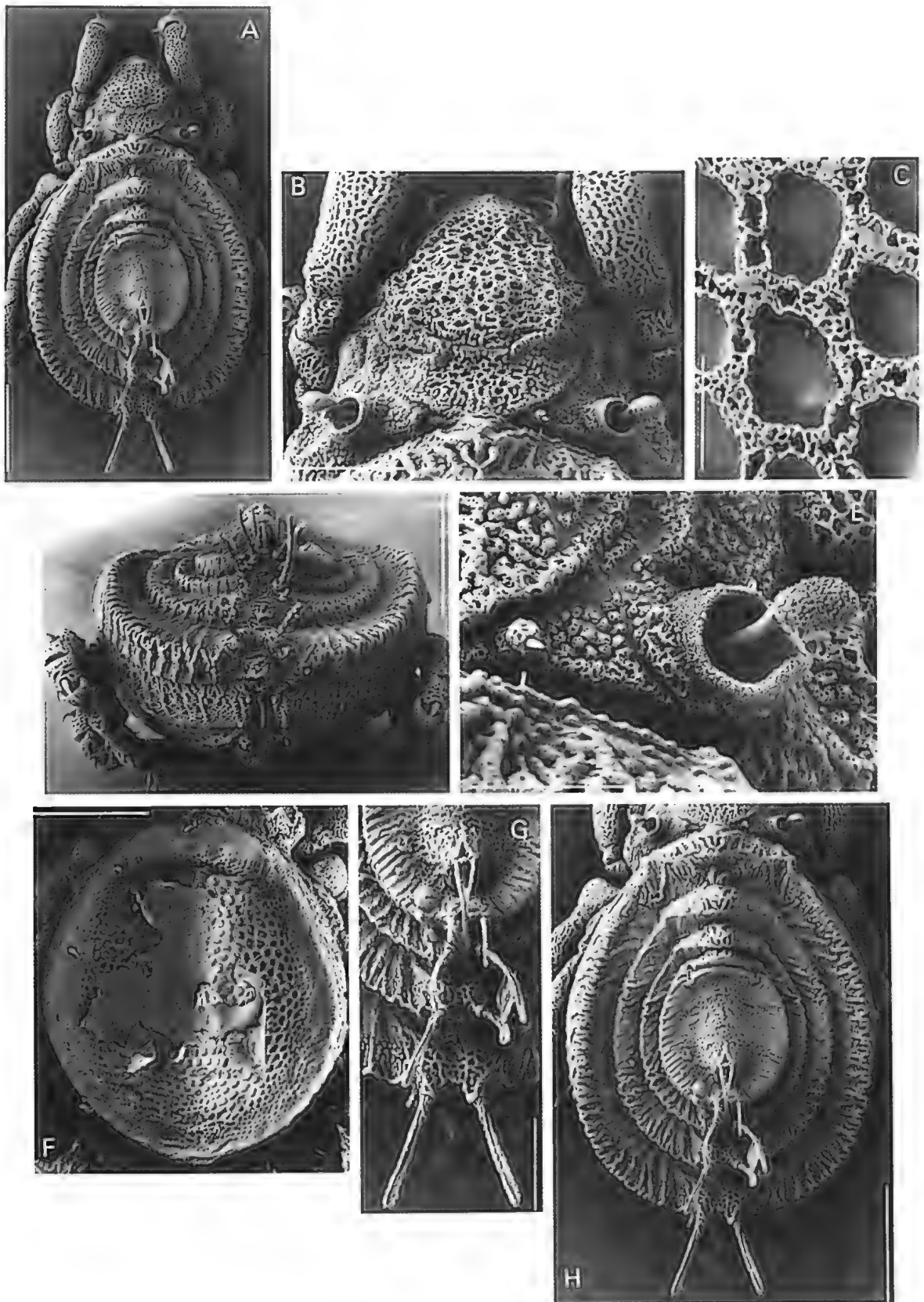
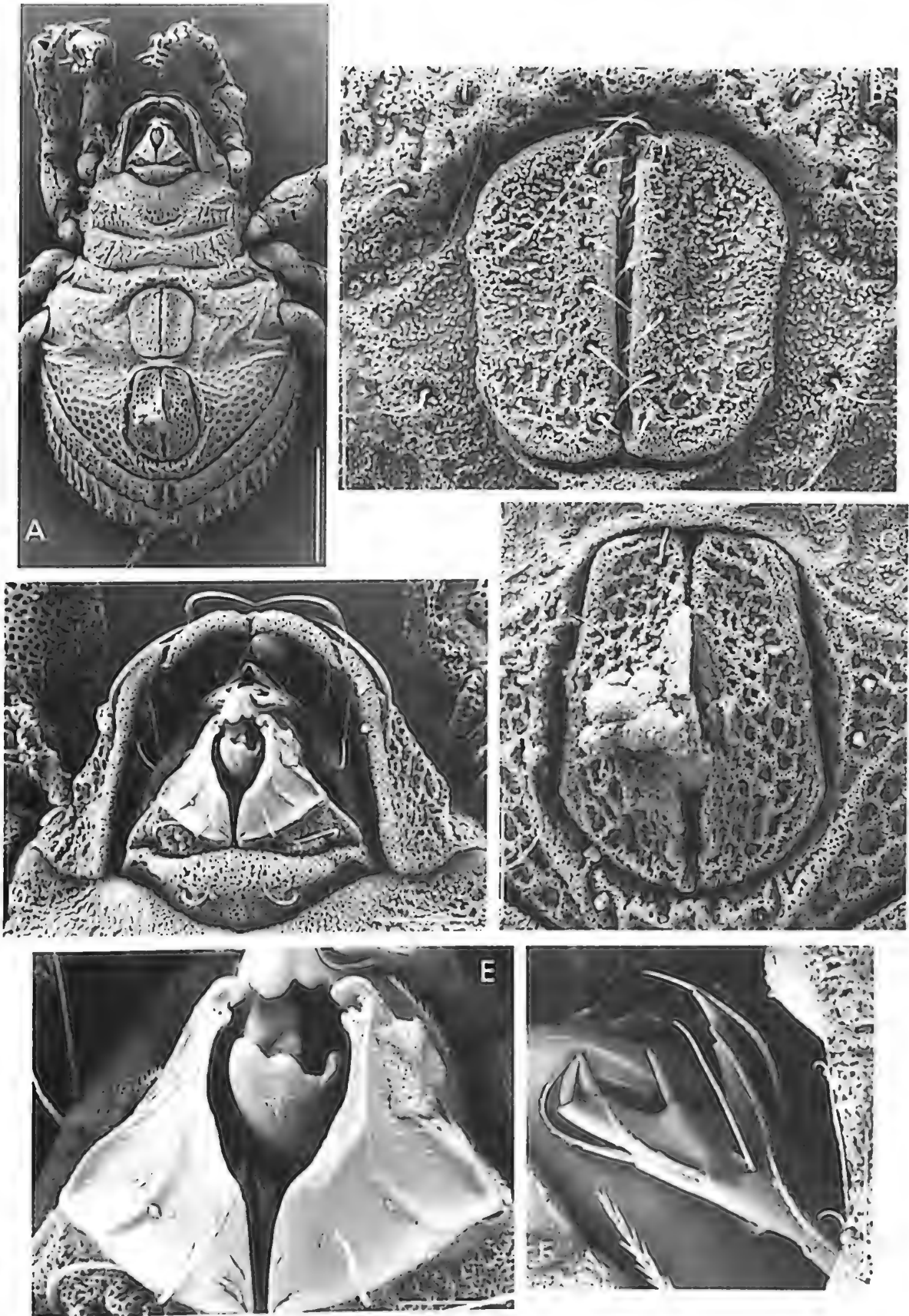


Fig. 5. *Labiogenes queenslandica* (P. Balogh). A, body, dorsal with exuvial scalps; B, prodorsum, dorsal; C, notogastral integument, detail; D, body, posterior; E, bothridium, sensillus and seta *in*, dorsal; F, notogaster, dorsal with scalps removed; G, detail of setae on scalps; H, exuvial scalps, dorsal. Scale bars: A, D, F, H = 200  $\mu$ m; B, G = 100  $\mu$ m; E = 50  $\mu$ m; C = 20  $\mu$ m.



**Fig. 6.** *Labiogen a queenslandica* (P. Balogh). A, body, ventral; B, genital valves; C, anal valves; D, subcapitulum; E, rutella; F, pedipalp tarsus, antiaxial. Scale bars: A = 200  $\mu$ m; B–D = 50  $\mu$ m; E, F = 20  $\mu$ m.



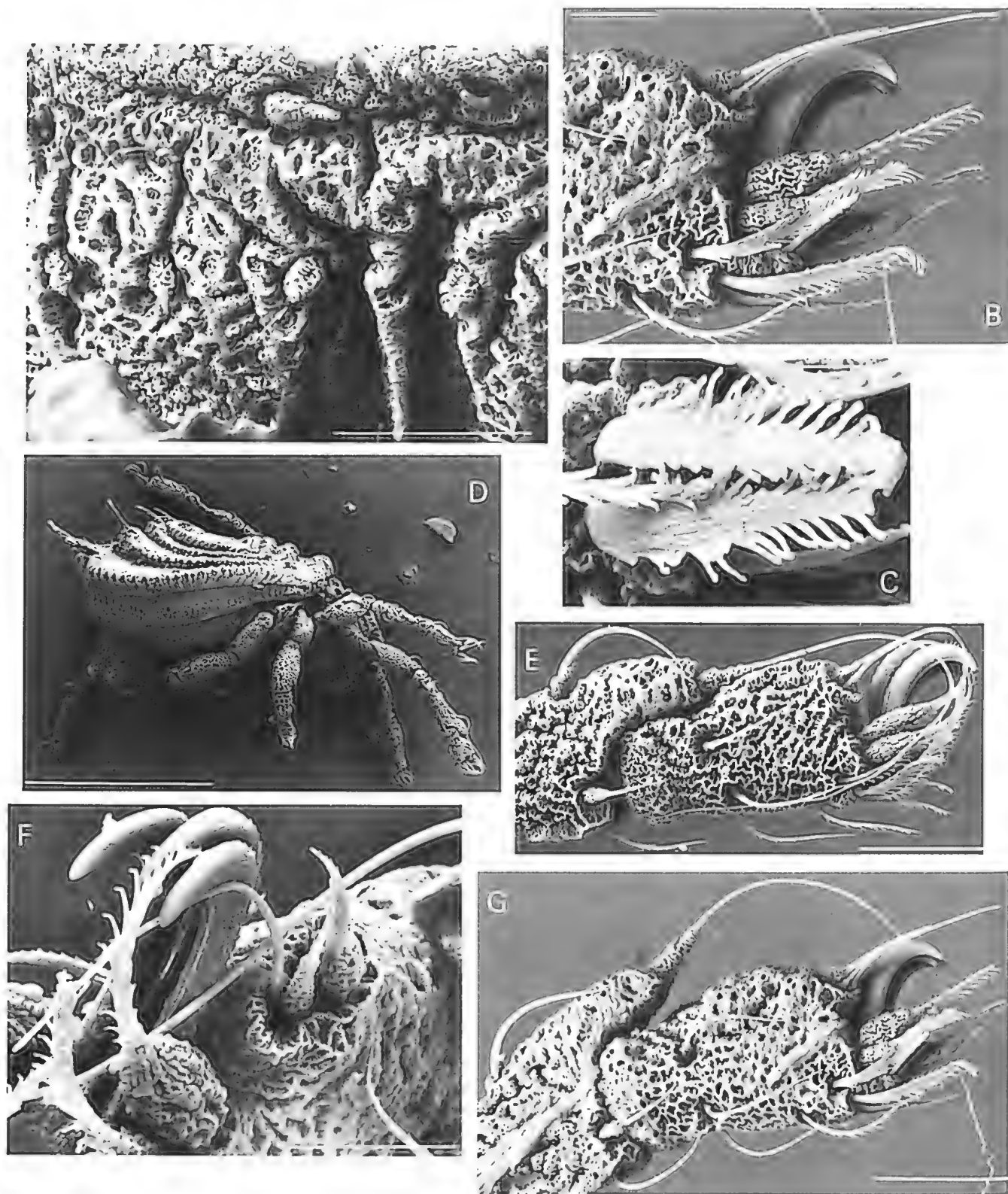


Fig. 7. *Labiogen a queenslandica* (P. Balogh). A, notogaster, posterior view, arrows left to right label setae *hl*, *pl*, *p2* and *p3* (*lp* apparently lost); B,F, leg I tarsus (distal), antiaxial and dorsodistal; C, distal tarsal setae, ventral; D, body, lateral with exuvial scalps; E,G, leg I tibia (distal) and tarsus, antiaxial. Scale bars: D = 500  $\mu$ m; A,E,G = 50  $\mu$ m; B,F = 20  $\mu$ m; C = 10  $\mu$ m. A-C,F,G = Bulburin; D,E = Mount Allyn.

inner anterior corner, *g5* at about 0.5 valve length; *g7* inserted well anterior to inner posterior corner, not in marginal notch; setae *ag* long, inserted at level between *g6* and *g7*; adanal setae short (Fig. 6C), *ad1* postanal, *ad2* and *ad3* close to each other at about 0.5 valve length, *ad3* only slightly further from anal valve (Fig. 1B). *Legs*. Apophysis of tibia I overrides 0.4 of tarsus (Fig. 7E). Tarsal cluster of leg I placed distodorsally, enclosed in low common rim (Fig. 7E,F), no partition separating *ft*" from *omega 1* and 2, latter close together, *omega 1* much longer than *ft*", opening to cavity containing undeveloped famulus not seen; terminal setae flattened (Fig. 7C), *tc*" and *it*" with thick basal coating of cerotegument; tarsus without distal recess for receiving retracted unguinal complex, stalk very short; iter setae on all tarsi including leg IV.

**Comments.** Peter Balogh (1985) noted the presence of two pairs of notogastral setae, but there are four pairs, *p2* and *p3* being inconspicuous and set low on posterior flank (Fig. 7A). The species habitually carries tightly adhering scalps. They were not noted by Balogh, possibly being removed from the holotype before illustration and description.

**Distribution.** Eastern Australia from Barrington Tops near Newcastle, New South Wales, to Bulburin, near Gladstone, Queensland.

### *Labiogena walteri* n.sp.

Figs 4C,E,F, 8, 9

**Type material.** New South Wales: HOLOTYPE adult. AM KS 48924, Mt Murray, Macquarie Pass, 34°33'S 150°38'E, rainforest tullgren extraction of bark from tree trunk, G.S. Hunt, 12 March 1996. PARATYPE adults: CNC, Dorrigo National Park, 30°22'S 152°47'E 1000 m, subtropical rainforest, ferns, L. Masner, 13 February 1984 (also non-type nymph probably of this species). AM KS46563 SEM stub no. S/301 (ill.), Macquarie Pass, 8 km E. of Robertson, 800 m, 34°35'S 150°38'E, laurel-sassafras rainforest, ferns, L. Masner, 8 February 1984, 1 adult; AM KS46564 SEM stub no. S/303 (ill.), New England National Park, 30°29'S 152°25'E, 1600 m, *Nothofagus moorei* forest, ferns, L. Masner, 12 February 1984, 1 adult; AM KS46565 SEM stub no. S/108, Allyn River, Chichester State Forest, 32°12'S 151°26'E, rainforest leaf litter, ANIC berlesate 748, T. Weir and A. Calder, 10/11 November 1981, 1 adult.

**Other material examined.** Queensland: AM KS46566 SEM stub no. S/320 (ill.), Lamington, 28°15'S 152°58'E, subtropical rainforest canopy, D.E. Walter, early 1994, 2 adults; University of Queensland Entomology Dept, same data, 3 adults (1 male, 1 female, 1 undetermined); University of Queensland Entomology Dept (slide, specimen on left), O'Reilly's, Lamington, 28°14'S 153°08'E ex canopy subtropical rain forest, R. Kitching, 1991.

### Diagnosis and description

**ADULT:** Similar to *L. queenslandica* except length about 680 µm; exuvial scalps with shorter caudal setae, those on scalp of nymph 3 arising from closely set mesal apophysis rather than widely set apophyses (Fig. 8A);

setae *hl* closer together than *p1* (Fig. 8F), setae *lp* present though very small; notogaster somewhat flatter and more dish-shaped (Fig. 8E), alveolate-reticulate (Fig. 8D); fissura *ia* closer to lateral margin; fissura *im* present, parallel to sagittal plane; notogastral seta *p2* set ventral to *p1* near base of posterior flank (Fig. 8F). *Gnathosoma*: rutella more convex with stronger transverse striations (Fig. 9B); solenidion on pedipalp tarsus not reaching base of *acm* (Fig. 9C). Cuticular thickenings on ventral plate stronger (Fig. 9A); *ad2* and *ad3* subequal in distance from anal valve (Fig. 9F).

**Variation.** The specimen from New England National Park has a very strong carina between setae *le* and *ro* (Fig. 8C).

**Comments.** This species is very close to *L. queenslandica*, the most obvious differences being in its flatter body, closer placement of the caudal setae of the exuvial scalps and the closer placement of setae *hl*.

**Etymology.** The specific epithet acknowledges the work of Dr David Evans Walter in studying the acarine ecology of forest canopies in eastern Australia.

**Distribution.** Eastern Australia from Macquarie Pass near Wollongong, New South Wales, to Lamington National Park near Brisbane, Queensland.

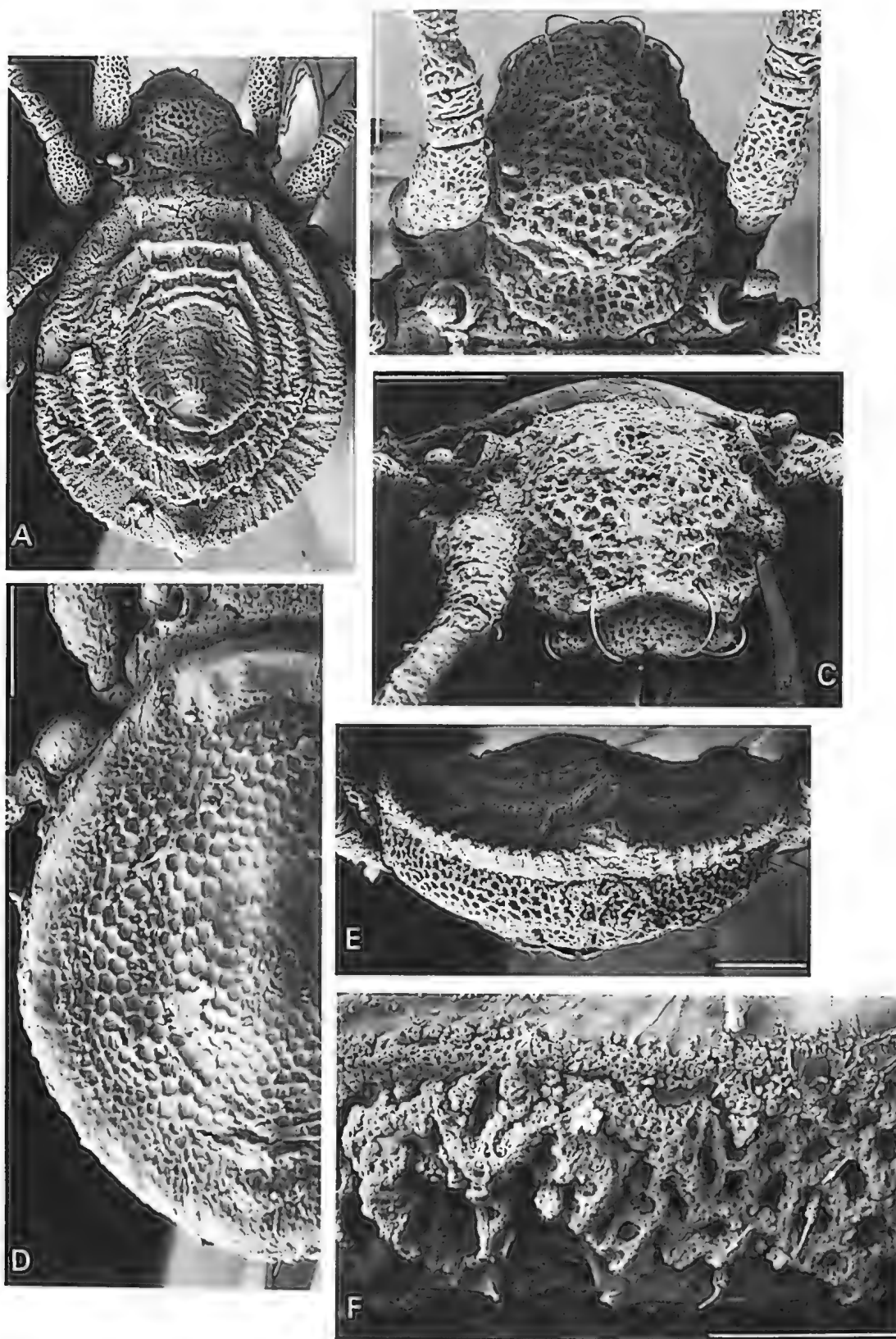
### *Novazelandiella* Paschoal, 1989b

*Novazelandiella* Paschoal, 1989b: 31; 1989c: 197.—Balogh & Balogh, 1992: 47.

**Type species.** *Pedrocortesella nigroclava* Hammer, 1966: 50, fig. 63, by original designation.

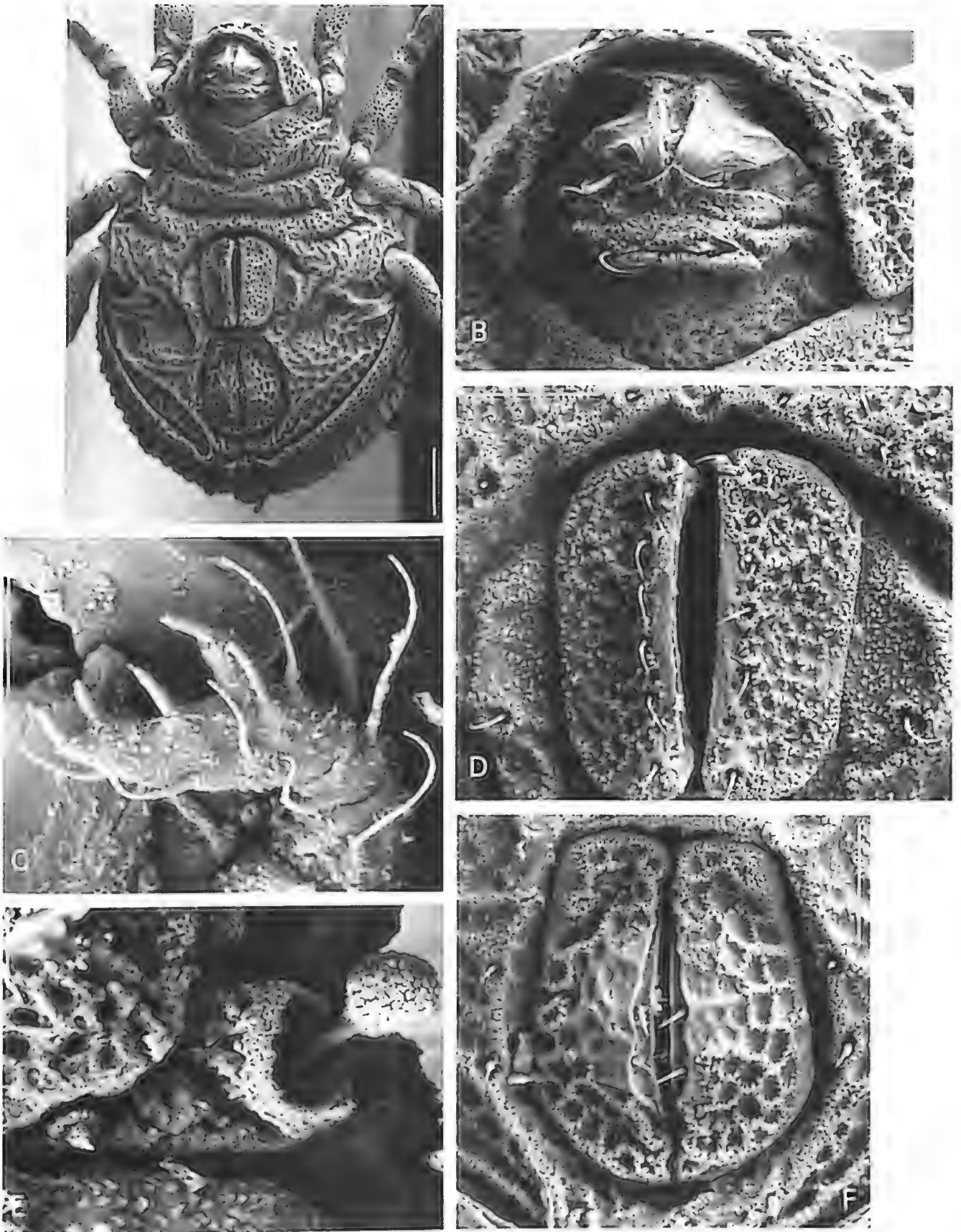
**Diagnosis.** Prodorsum without transverse furrow, enantiophyses absent; sensillus a petiolate globe held largely within broad basin-like bothridium; adults carry exuvial scalps; subcapitulum without mental tectum; rutella without transverse striations; seta *ag* lateral to genital valves; genital valves rectangular, subequal in length to anal valves; 2(?) pairs of anal setae, 3 pairs adanal, *ad3* subequal to *ad2* in distance from anal valves; femoral and trochanteral tracheae present; distal compression of tarsus I extreme, tarsal cluster of leg I oriented distodorsad on apophysis, terminal setae flattened; iter setae present on all leg tarsi.

**Comments.** Paschoal's (1989b) redescription of the type species is largely based on non-type material which he believes is conspecific to the type specimen. He describes the species as having three pairs of anal setae, seta *ad3* away from the anal plate and seta *ex* present. On examining the type specimen, I could only see two pairs of anal setae (though this area of the specimen is hard to decipher), a seta *ad3* subequal in distance from the anal valve to *ad2* (though the specimen is contaminated with "seta-like" crystals) and I am unsure about the presence of *ex*. The Australian species described below, which clearly is closely related to *N. nigroclava*, has two pairs of anal setae, a seta *ad3* close to the anal valve, and apparently no seta *ex*.



**Fig. 8.** *Labiogena walteri* n.sp. A, body, dorsal with exuvial scalps; B, prodorsum, dorsal; C, prodorsum, frontal; D, notogaster (part), dorsal without scalps; E, notogaster, posterior with scalps; F, notogaster, posterior view, arrows left to right label setae *h1*, *p1*, *lp*, *p2* and *p3*. Scale bars: A = 200 µm; B-E = 100 µm; F = 50 µm. A,B,E,F = Macquarie Pass; C,D = New England National Park.





**Fig. 9.** *Labiogenia walteri* n.sp. A, body, ventral; B, subcapitulum; C, pedipalp tarsus, antiaxial; D, genital valves; E, bothridium, sensillus and seta *in*, dorsal; F, anal valves. Scale bars: A = 100 µm; B,D-F = 50 µm; C = 20 µm. A,B,D-F = Macquarie Pass; C = Lamington National Park.

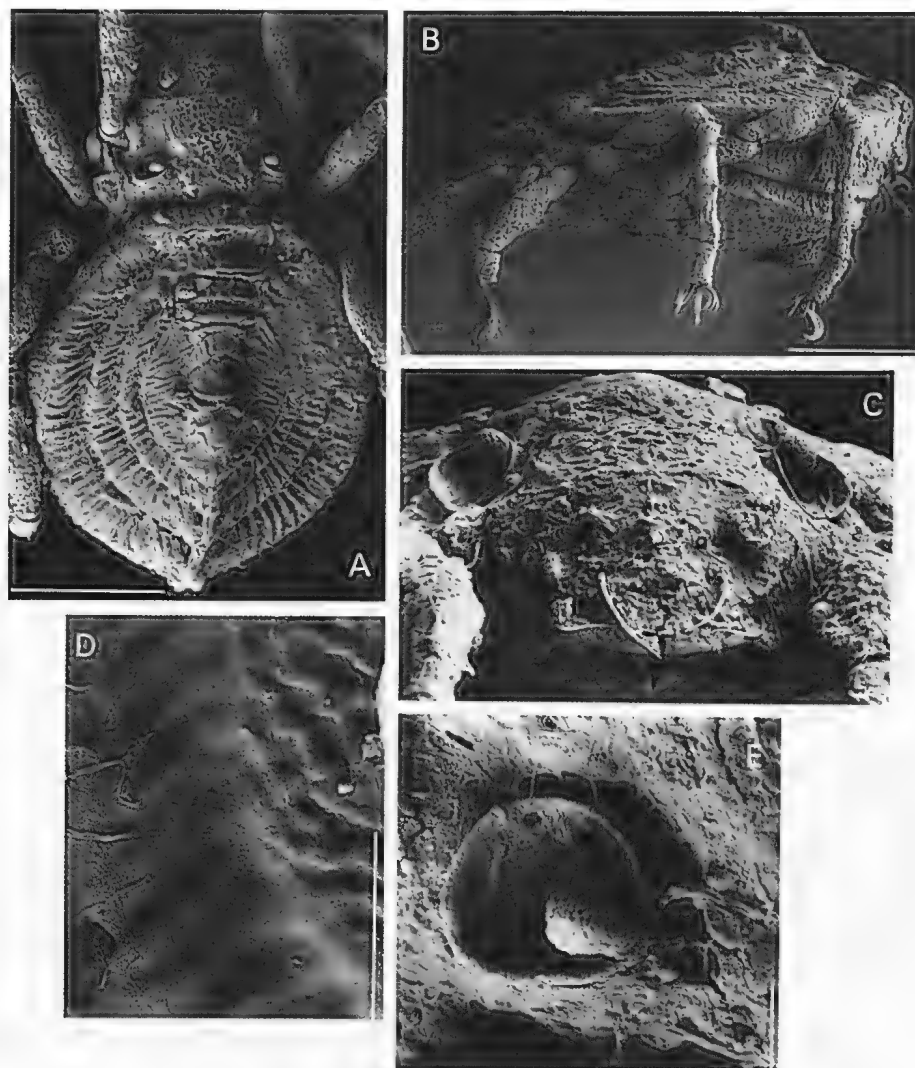


Fig. 10. *Novazelandiella kellyi* n.sp. A,B, Body, dorsal and lateral, with exuvial scalps; C, prodorsum, frontal; D, notogastral integument, detail; E, bothridium and sensillus, dorsal. Scale bars: A,B = 200  $\mu$ m; C,D = 50  $\mu$ m; E = 20  $\mu$ m.

Paschoal's (1989a) placement of the genus in the family Hammeriellidae Paschoal is discussed below (see General Discussion).

### *Novazelandiella kellyi* n.sp.

Figs 10, 11

**Type material.** New South Wales: HOLOTYPE adult. AM KS46571 SEM stub no. S/229 (ill.), Dorrigo National Park, 30°22'S 152°47'E, sassafras canopy at 21m, D.E. Walter, 12 March 1993.

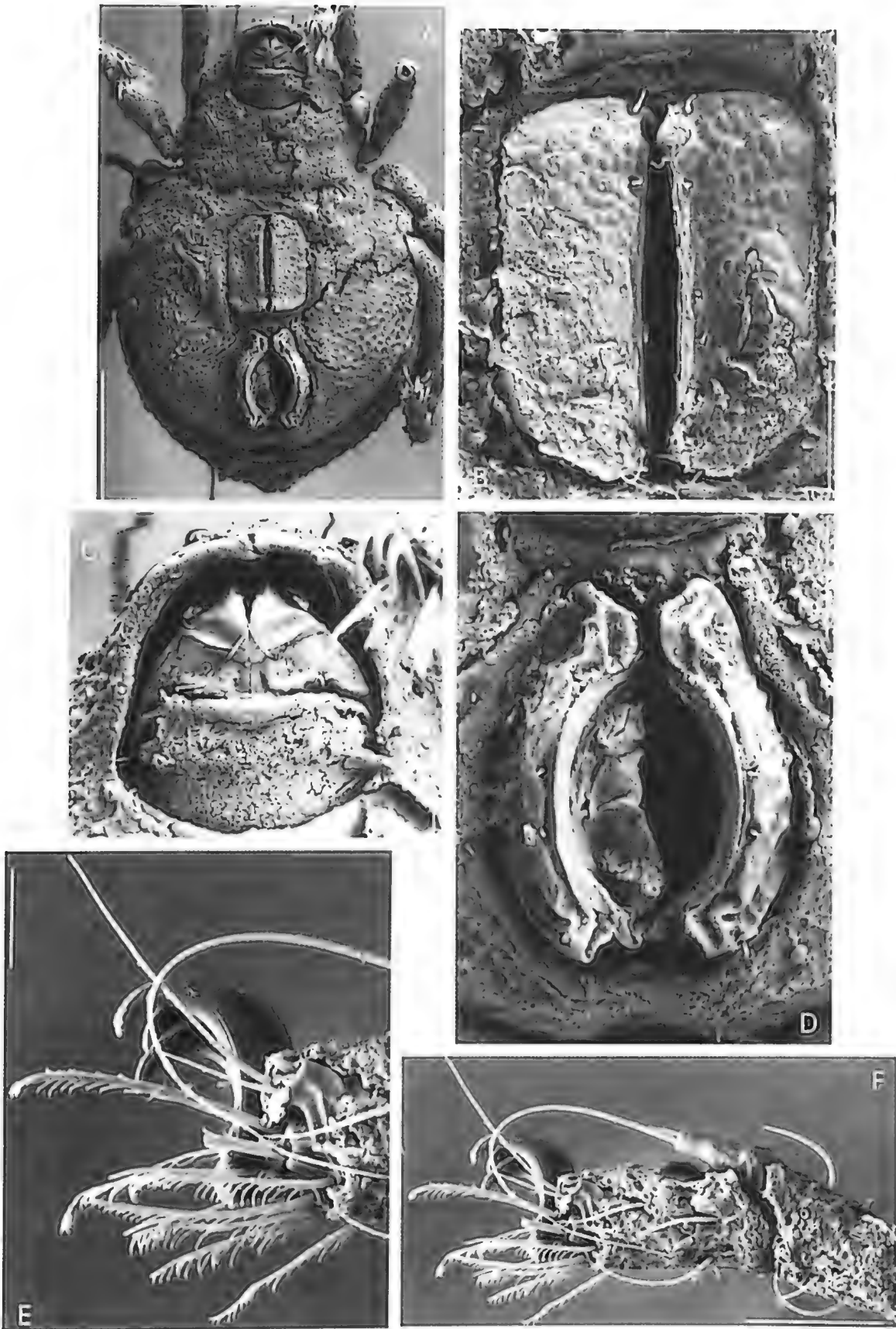
Queensland: PARATYPE adults. QM, SEM stub no. S/426, Lamington, 28°15'S 152°58'E, subtropical rainforest canopy, D.E. Walter, early 1994, 2 adults.

**Other material examined.** Queensland: University of Queensland Entomology Dept (slide, specimen on right), O'Reilly's, Lamington, 28°14'S 153°08'E, ex canopy subtropical rain forest, R. Kitching, 1991.

**Diagnosis.** Similar to *N. nigroclava* except 2 pairs of anal setae, notogastral setae *p1*, *p2*, *p3* on posterior flank, no setae anterior to fissura *ip*.

### Description

**ADULT: Body:** brown, sensillus black; length about 700  $\mu$ m. **Cerotegument:** body and legs generally with thick veneer of cerotegument. **Prodorsum:** broad; transverse furrow absent; integument without reticulate-foveate pattern; no carina between *le* and *ro* but weak transverse ridge between bothridia and lamellar setae (Fig. 10A,C); *le* dorsolateral and situated close to anterior of rostrum, distance between them about 0.6 distance between *ro*, *ro* ventrolateral, curved strongly mesad, *ex* not seen under SEM or LM. Pedotectal tooth short, not greatly curved, with strong laterad swelling of prodorsum at its base. Bothridium about its diameter from notogaster, broad, basin-like, in which globose sensillus with short petiole sits like a pea (Fig. 10C,E), wall subcircular,



**Fig. 11.** *Novazelandiella kellyi* n.sp. A, body, ventral; B, genital valves; C, subcapitulum; D, anal valves; E, leg I tarsus (distal), antiaxial; F, leg I tibia (distal) and tarsus, antiaxial. Scale bars: A = 200  $\mu$ m; B–D,F = 50  $\mu$ m; E = 20  $\mu$ m.

posterolateral carina absent; no carinae between bothridia; *in* a small spine separated from bothridium subequal to bothridial diameter (Fig. 10C). *Exuvial scalps*: with median crest, forming a blunt point posteriorly rather than more gently rounded (Fig. 10A). *Notogaster*: oval, central part with weak foveae, which give way to more irregular wavy ridges laterally (Fig. 10D); posterior margin not invaginate when viewed from above and somewhat overhangs posterior flank. 5 pairs of notogastral setae, *h1* strongest and most dorsal, *lp* close to it; *p1* ventral to *h1* and *p2* and *p3* smaller and further lateral and ventral to *p1*. *Gnathosoma*: rutella with concave flexure (Fig. 11C). Pedipalp tarsus with weak apophysis supporting seta *acm*, solenidion reaching base of *acm* (setal barbs could not be seen under LM). *Epimeral region*: weakly convex anterior to genital valves. *Genitoanal region*: separation of anal and genital vestibules relatively narrow with interruption to ventral plate microsculpture (Fig. 11A). Ventral plate reticulate-foveate, cuticular thickenings immediately adjacent to genital valves (Fig. 11A); genital valves rectangular, subequal in length to anal valves. Genitoanal chaetotaxy 7:1:2:3; genital setae essentially in straight file (Fig. 11B), *g1* at inner anterior corner, *g5* at about 0.7 valve length; *g7* inserted near inner posterior corner (Fig. 11B); setae *ag* inserted at level just posterior to *g6*; adanal setae short (Fig. 11D), *ad1* immediately postanal, *ad2* and *ad3* subequal in distance from anal valve. *Legs*. Very long; apophysis of tibia I overrides 0.4 of tarsus (Fig. 11F). Tarsal cluster of leg I a compact group placed distodorsally on apophysis lying antiaxial to retracted claw complex (Fig. 11E), *omega 1* and 2 close together, *omega 1* very long, much longer than *fi*"; alveolus for undeveloped seta *epsilon* not seen; terminal setae flattened with long marginal barbs (Fig. 11E), tarsus without distal recess for receiving retracted unguinal complex, stalk very short.

**Etymology.** The specific epithet acknowledges Jon Kelly who has helped me with computer work involved in the production of a CD-ROM for the identification of oribatid mites.

**Distribution.** Eastern Australia: Dorrigo National Park near Dorrigo, New South Wales, to Lamington National Park near Brisbane, Queensland.

### *Darthvaderum* n.gen.

**Type species.** *Darthvaderum greensladeae* n.sp.

**Diagnosis.** Prodorsum with very shallow transverse furrow, enantiophyses absent; sensillus a petiolate club, not a blade; seta *ex* absent; adults frequently carry exuvial scalps; 5 pairs of notogastral setae, *p2* adjacent to *p1*; subcapitulum without mental tectum, rutellum with transverse striations; epimeral chaetotaxy 3:1:3:3; genitoanal chaetotaxy 7:1:3:3, seta *ag* lateral to genital

valves, *ad3* more laterad than *ad2*; femoral and trochanteral tracheae present; distal compression of tarsus I strong, tarsal cluster of leg I oriented distodorsad; iter setae present on all leg tarsi.

**Comments.** The genus corresponds to Paschoal's definition of the family Hammeriellidae in having three pairs of anal setae, (virtual) absence of a transverse furrow on the prodorsum, and in possessing iter setae on the tarsus of leg IV. Some comments on the validity of the family are given below (see General Discussion).

**Etymology.** When I saw the SEM of the gnathosoma I immediately thought of Darth Vader, evil antihero of Star Wars. Gender is neuter.

### *Darthvaderum greensladeae* n.sp.

Figs 1C,D, 12–14

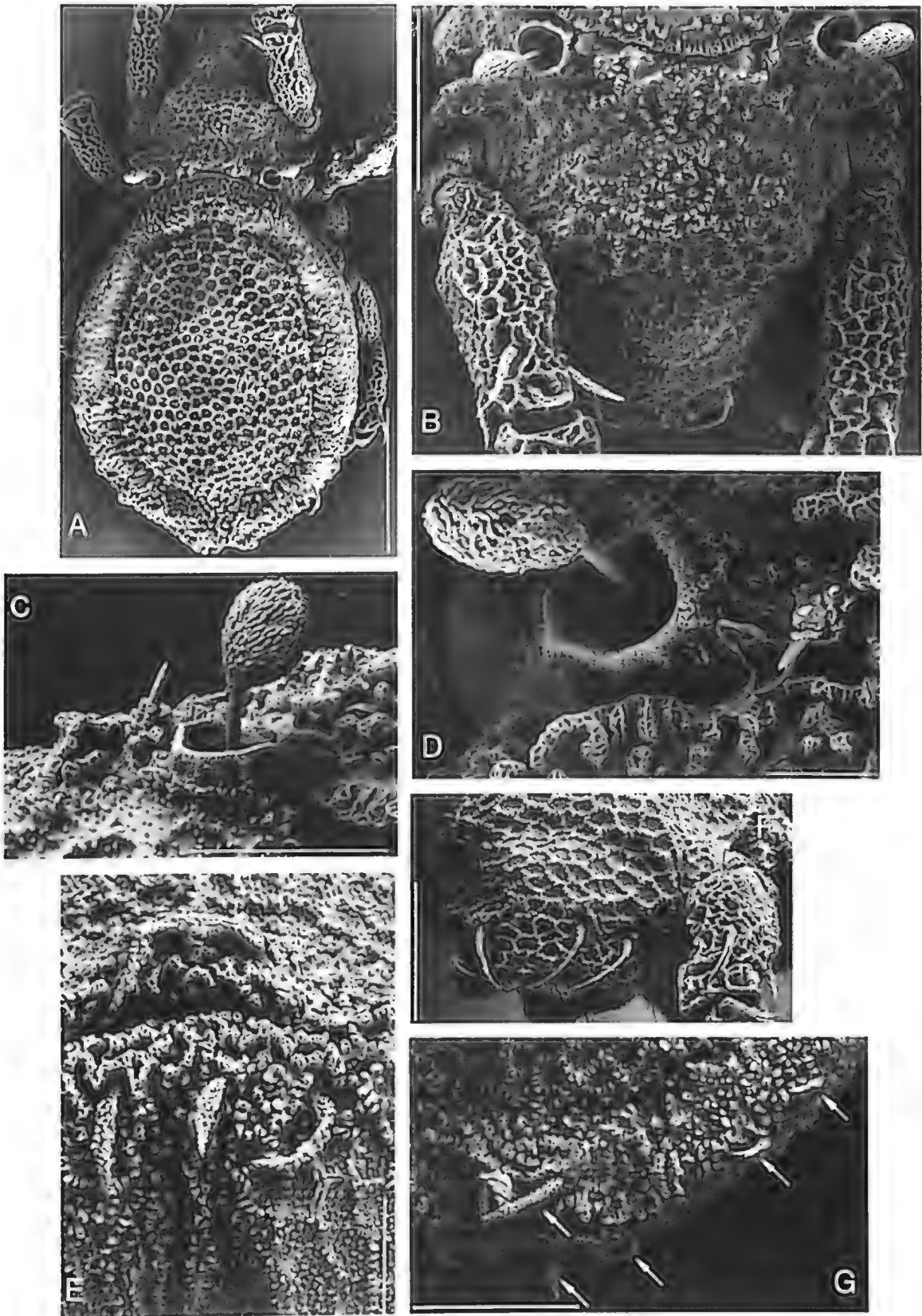
**Type material.** Tasmania: HOLOTYPE adult. ANIC, Mount Michael, 41°10'S 148°00'E, pyrethrum knock-down from tree, R. Coy, 28 November 1989. PARATYPE adults. AM KS46572, SEM stub no. S/272 (ill.), same data as holotype, 2 adults; AM KS46573 SEM stub no. S/271 (ill.), same data, 1 adult; AM KS43748, same data, 3 adults; ANIC, same data, 3 adults; CNC, same data, 2 adults; FMNH, same data, 1 adult; QM, same data, 1 adult.

**Diagnosis.** As for genus.

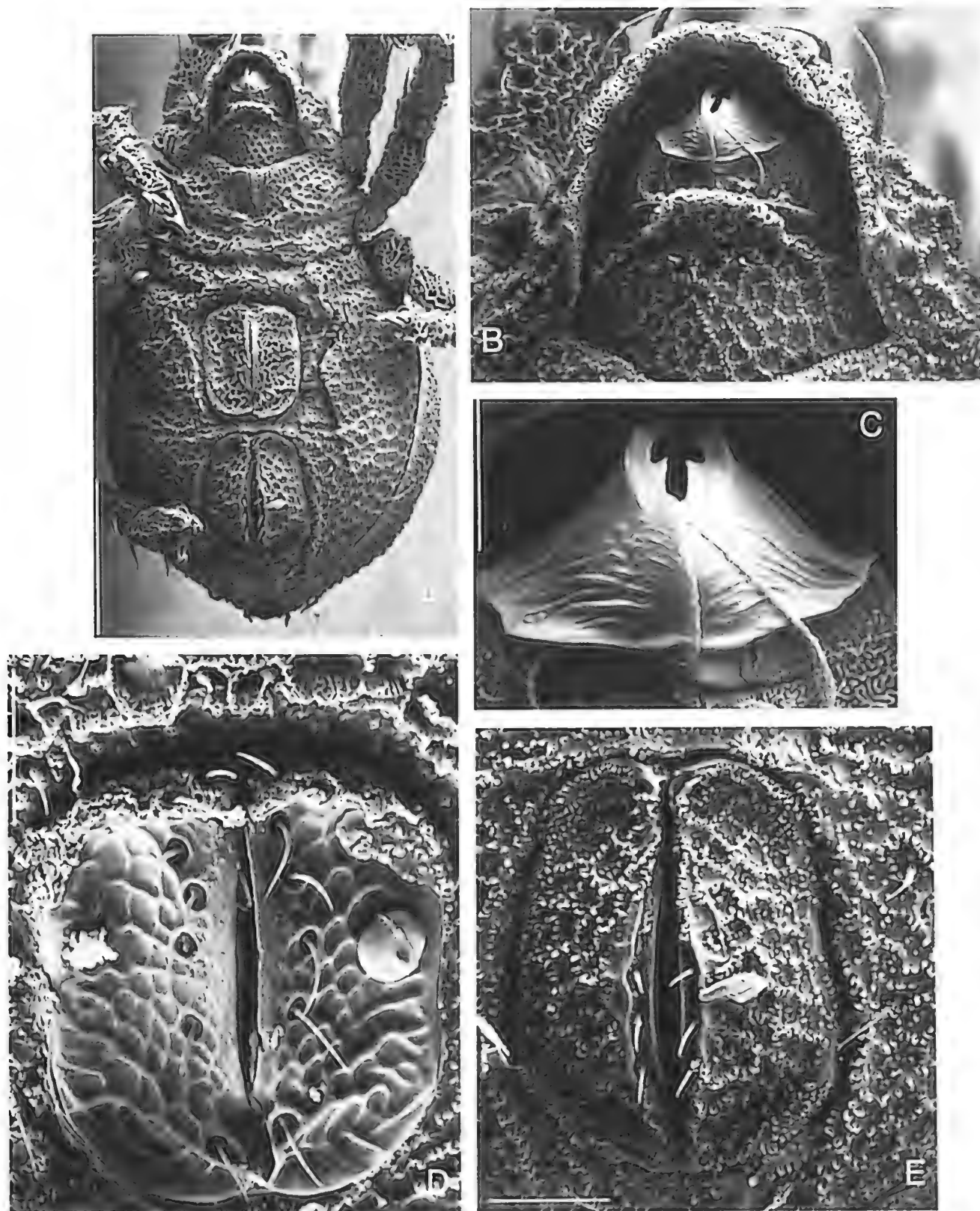
### Description

**ADULT: Body:** dark brown, sensillus black; length about 740 µm. **Cerotegument:** body generally with thin veneer of cerotegument with coarse stellate tubercles which may coalesce into blocky crests on areas of higher relief (Fig. 14C); notogastral setae with thick accumulations. **Prodorsum:** transverse furrow very shallow (Fig. 14D); integument reticulate-alveolate; no carina between *le* and *ro* (Fig. 12F); rostrum extended anteriorad, usually appearing translucent under dissecting microscope; *le* dorsolateral and situated close to anterior of rostrum, strongly curved mesad, distance between them about 0.6 distance between *ro*, *ro* lateral, insertion barely visible from above. Pedotectal tooth tapering gradually to blunt tip; bothridium abutting notogaster but not closely adpressed, wall subcircular and slightly excavate posteriorly (Fig. 12C,D); rim with lateral beak but posterolateral carina weak (Fig. 12C); sensillus a tuberculate ovoid club arising from a faintly granular petiole above bothridial rim; *in* small, spinous, on small apophysis, separated from bothridium by less than bothridial diameter, set at edge of dorsosejugal furrow and directed posterad (Fig. 12D). **Exuvial scalps:** anterior margins closely juxtaposed, posterior margins well separated (Fig. 14A). Most specimens do not carry

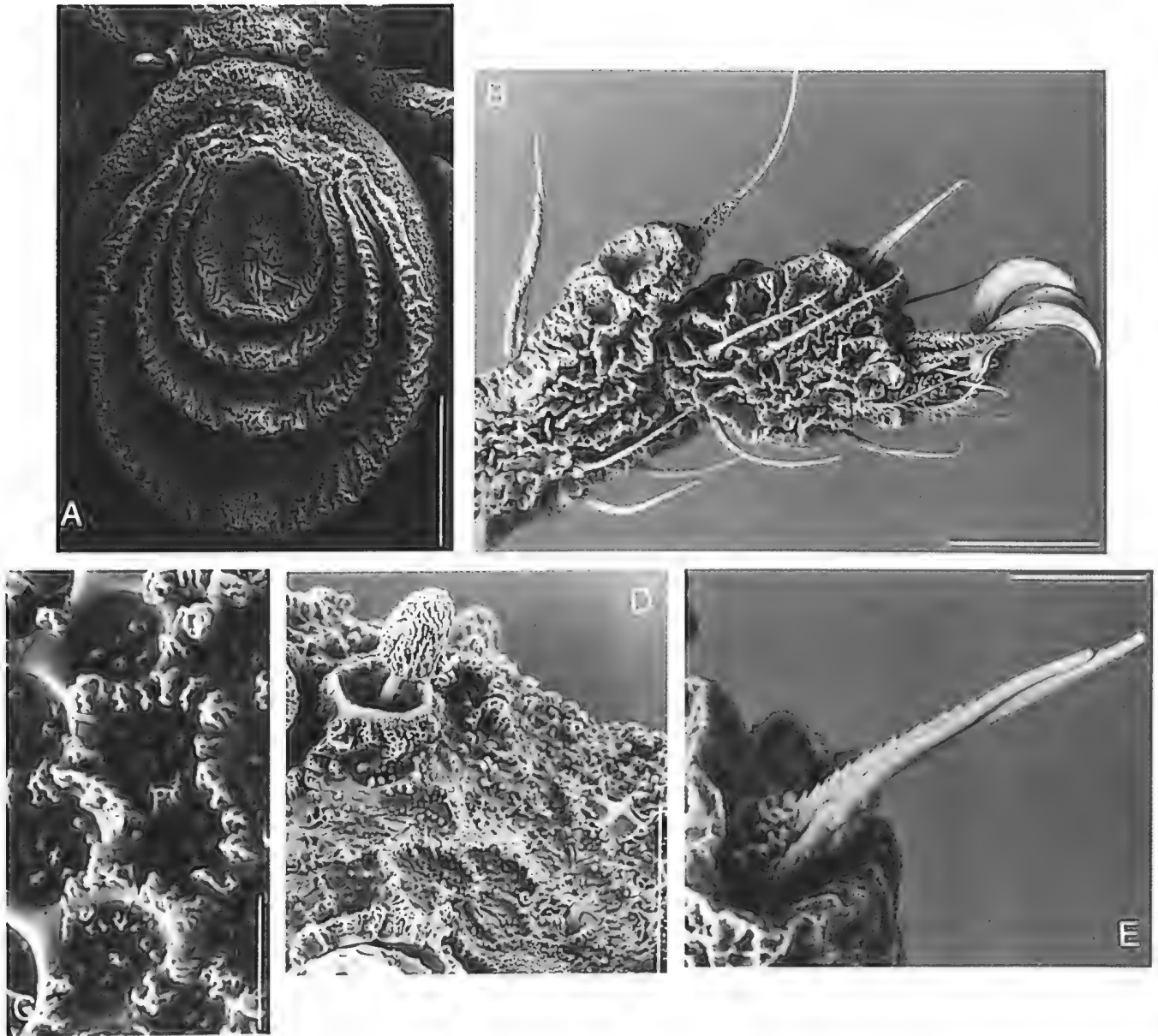




**Fig. 12.** *Darthvaderum greensladeae* n.sp. A, body, dorsal without exuvial scalps; B, prodorsum, dorsal; C,D, bothridium, sensillus and seta *in*, lateral and dorsal; E, caudal region of notogaster, posterior view, showing setae *h1*, *p1* and *p2*; F, rostrum, frontal; G, notogaster, posterior portion, dorsal, arrows left to right label setae *h1*, *p1*, *p2*, *lp<sub>x</sub>* and *p3<sub>x</sub>*. Scale bars: A = 200  $\mu$ m; B,F,G = 100  $\mu$ m; C,E = 50  $\mu$ m; D = 20  $\mu$ m.



**Fig. 13.** *Darthvaderum greensladeae* n.sp. A, body, ventral; B, subcapitulum; C, rutella; D, genital valves; E, anal valves. Scale bars: A = 200  $\mu$ m; B,D,E = 50  $\mu$ m; C = 20  $\mu$ m.



**Fig. 14.** *Darthvaderum greensladeae* n.sp. A, exuvial scalps, dorsal; B, leg I tibia (distal) and tarsus, antiaxial; C, notogastral integument, detail; D, bothridium and sensillus and weak transverse furrow on prodorsum, lateral; E, leg I tarsal cluster, antiaxial. Scale bars: A = 200  $\mu$ m; B,D = 50  $\mu$ m; C = 20  $\mu$ m; E = 10  $\mu$ m.

scalps. *Notogaster*: oval, length:width without scalps 580:410, intramarginal depression oval with distinct break between central subregular alveolate-reticulate field and bordering field with smaller alveoli of lower relief (Fig. 12A); posterior margin slightly invaginate when viewed from above, with very weak carina flanked by grooves between setae *p1* when viewed posteriorly (Fig. 12E). Fissurae short, *ia* oblique to sagittal plane, *im* perpendicular-oblique, *ip* parallel to plane; 5 pairs of notogastral setae, *h1* close just inside posterior margin, *p1* similarly spaced on posterior flank, *p2* adjacent to *p1* (Figs 1,C,D; 12E), *lp<sub>x</sub>* and *p3<sub>x</sub>* anterior to fissura *ip* at same level as *h1*, no setae very close

to fissura *ip* (Fig. 12G). *Gnathosoma*: rutella predominantly convex, strong transverse striations, anteromesal notch of distinct form (Fig. 13C); mentum anteriorly with very strong transverse carina; pedipalp not studied. *Epimeral region*: strongly convex anterior to genital valves, but not tending to overhang them. *Genitoanal region*: separation of anal and genital vestibules relatively narrow with interruption to ventral plate microsculpture (Fig. 13A). Ventral plate reticulate-alveolate, cuticular thickening immediately adjacent to both genital and anal valves (Fig. 13A). Genital setae long, essentially in arcuate file (Fig. 13D), *g1* at inner anterior corner, *g2* close to but laterad of *g1*, *g5* at about



0.4 valve length; *g7* inserted well anterior to inner posterior corner, not in marginal notch; setae *ag* long, inserted at level just anterior to *g7*. Seta *ad1* postanal, *ad3* most laterad, its insertion adjacent to anterior 0.3 of anal valve (Figs 1D; 13E). Legs. Apophysis of tibia I overrides 0.3 of tarsus (Fig. 14B). Tarsal cluster of leg I placed distodorsally, enclosed in low common rim (Fig. 14E), no partition separating *ft*" which is closely adpressed to *omega* 1 and 2, latter close together, alveolus for undeveloped seta *epsilon* not seen; terminal setae slightly flattened, *tc*" and *it*" with thick basal coating of cerotegument; tarsus without distal recess for receiving retracted unguinal complex, claw stalk medium.

**Etymology.** The specific epithet acknowledges Dr Penny Greenslade who organised the Tasmanian Rainforest Survey on which much interesting oribatid material was collected, including the present species.

**Distribution.** North-eastern Tasmania: Mount Michael.

### General Discussion

The above genera are provisionally placed in the family Hammeriellidae Paschoal on the basis of the absence of a well-developed transverse furrow on the prodorsum and the presence of iter al setae on all leg tarsi, including leg IV.

However, the type genus, *Hammeriella*, appears to belong to the Pheroliodidae, possibly allied to *Lopholiodes*. Contrary to Paschoal (1989a), the type material of *Hammeriella grandis* (Hammer) does appear to have a transverse furrow on the prodorsum bearing enantiophyses though squashing during slide preparation has partly masked these features. Such enantiophyses are diagnostic of the Pheroliodidae and, indeed, Hammer originally placed the species in *Pedrocortesia*, now regarded as a junior synonym of *Pheroliodes*. Presence of iter al setae on all leg tarsi is a character which *Hammeriella* shares with the pheroliodid genus *Lopholiodes* (Paschoal, 1989c). The status of the Hammeriellidae is therefore in doubt.

It is predicted that a phylogenetic analysis of the Plateremaeoidea will show that Hammeriellidae should be regarded as a junior synonym of Pheroliodidae.

*Novazelandiella*, *Labiogena* and *Darthvaderum*, however, do not have enantiophyses on a transverse furrow and therefore do not belong in the Pheroliodidae *sensu* Hunt & Lee (1995). The presence of iter al setae on all legs in these taxa could well prove to be a plesiomorphic character, insufficient by itself to unite them in a separate family.

The three genera described above also possess a capitate sensillus, thought to be an adaptation to arboreal life (see, for example, O'Dowd *et al.*, 1991). Its evolution in these taxa, and in *Hammeriella*, *Andesperuviella*, *Hexachaetoniella* and at least two species of *Pedrocortesia* (Hunt, 1996a) may have occurred independently, representing separate forays into the arboreal habitat.

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## A Review of the Family Pheroliodidae Paschoal in Australia (Acarina: Cryptostigmata: Plateremaeoidea)

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**ABSTRACT.** The paper reviews the family Pheroliodidae (Plateremaeoidea) in Australia and a rediagnosis is given for the type genus, *Pheroliodes*. A monotypic genus *Neonooliodes* n.gen. is established for *N. ceroplastes* n.sp. Eight new *Pheroliodes* species are described: *P. springthorpei* n.sp., *P. barringtonensis* n.sp., *P. concavus* n.sp., *P. lindsayae* n.sp., *P. lordhowensis* n.sp., *P. monteithi* n.sp., *P. sicarius* n.sp. and *P. transversus* n.sp. *Octoliodes robustus* (Hunt & Lee) is recombined from *Pheroliodes*, a supplementary description and new records given, and a rediagnosis given for genus *Octoliodes*. A key is given for the 11 Australian species currently placed in the Pheroliodidae. Characters of special significance for the family are discussed. A key is presented for ten plateremaeoid genera represented in Australia.

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This paper is the fourth in a series on Australian Plateremaeoidea *sensu* Marshall *et al.* (1987). It focusses on the Pheroliodidae and particularly *Pheroliodes* Grandjean, the second most speciose genus in the superfamily in Australia after *Pedrocortesella* Hammer (Hunt, 1996a,b,c).

Australian species mostly inhabit ground litter and soils, though *Octoliodes robustus* n.comb. can be very common on tree trunks in moist areas. The family has an essentially Gondwanan distribution, having been recorded from South America, New Zealand, Australia and South Africa, but outliers occur in Florida and in the Mediterranean region.

South American species placed in the family include 16 *Pheroliodes* species (Grandjean, 1964; Covarrubias,

1968; Hammer, 1958; Fernandez, 1987; Paschoal, 1987; Fernandez *et al.*, 1991; Baranek, 1984; 1986; Woas, 1992) and two species in *Lopholiodes* Paschoal (Paschoal, 1987). *Pheroliodes* also occurs in the Galapagos Islands (H. Schatz, pers. comm.), and one species has been recorded from Florida (Marshall *et al.* 1987). New Zealand includes two species originally placed in *Pedrocortesella* Hammer but subsequently placed in the genus *Octoliodes* by Paschoal (1987). There is a questionable record of *Pheroliodes* from South Africa (Balogh & Mahunka, 1966) and *Nooliodes glaber* (J. Balogh) from Madagascar may be referable to the Pheroliodidae (see below). Mediterranean region records include two *Licnoliodes* species which Paschoal (1987) places in the Pheroliodidae. Species from the eastern

Palaearctic ascribed to *Pedrocortesia*, for example by Ryabini (1986), apparently belong in *Pedrocortesella* or closely allied taxa (Hunt, 1996a).

The Australian pherolioidid fauna now comprises 11 species, including nine species in *Pheroliodes* (see key below).

### Methods

Descriptions apply to adults only. *Pheroliodes springthorpei* n.sp. is described first as an exemplar and descriptions of other species follow, arranged in alphabetical order. A Cambridge Stereoscan 120 with Robinson Detector was used for SEM. The holotype of the type species and holotypes of Hammer's New Zealand species and P. Balogh's Australian species have been examined. The following abbreviations are used to indicate the present location of material: AM—Australian Museum, Sydney; ANIC—Australian National Insect Collection, Canberra; CNC—Canadian National

Collections of Insects, Arachnids and Nematodes, Ottawa; ELU—Zoosystematical and Ecological Institute, Eotvos Lorand University, Budapest; FMNH—Field Museum of Natural History, Chicago; QM—Queensland Museum, Brisbane; SAMA—South Australian Museum, Adelaide; WAM—Western Australian Museum, Perth; ZMK—Zoologisk Museum, Kobenhavn.

Specimens are preserved in alcohol unless otherwise stated.

Many structures referred to in descriptions and the key are illustrated with their abbreviations in Figure 1 of Hunt (1996a) and Fig. 22 below. The systems of notogastral and leg setal notation used in this paper follow Grandjean (1964). Measurements are in micrometers and ratios of notogaster length to width in descriptions are given in the actual measures, e.g., 540:460, for each specimen measured. The abbreviation "ill." means the SEM was used to illustrate the species in descriptions. Illustrations used in Figures are of specimens from the type locality unless otherwise stated.

### Systematics

#### Key to adults of plateremacoid genera in Australia

N.B., for identification under transmitted light the animal should be cleared. Scalps, if present, should be noted and removed to make examination easier)

- 1 Prodorsum with enantiophyses present on transverse furrow (Fig. 1C) ..... (Pherolioididae) 2
- Prodorsum without enantiophyses on transverse furrow ..... 4
- 2 Prodorsum anterior to transverse furrow foveate (Fig. 1C) or unpatterned (Fig. 16B) ..... *Pheroliodes* Grandjean
- Prodorsum anterior to transverse furrow conspicuously reticulate (Fig. 17B) ..... 3
- 3 Notogaster dorsally faintly reticulate-alveolate (Fig. 19A); ventral plate strongly reticulate (Fig. 20A)..... *Neonooliodes* n.gen.
- Notogaster dorsally strongly foveate (Fig. 17F); ventral plate not reticulate but may be heavily folded (Fig. 18A) ..... *Octoliodes* Paschoal
- 4 Sensillus filiform; notogaster more or less uniformly concave or saucer-shaped with rim the highest contour ..... *Plateremaeus* Berlese
- Sensillus with a narrow petiole but expanding distally into a flat blade or rounded club; notogaster flattened or convex centrally, with or without concave areas ..... 5
- 5 Notogaster covered with tangled threads of cerotegument; leg segments very long, narrow basally, and bearing long setae cloaked in cerotegument ..... genus allied to *Gymnodamaeus* Kulczynski  
(Australian species not studied in detail)
- Notogaster and legs not with these attributes ..... 6

- 6 Sensillus terminating in a flattened blade..... *Pedrocortesella* Hammer
- Sensillus terminating in an ovoid or spherical club ..... 7
- 7 Notogaster with a seta (seta *lm*) or its alveolus mesad of (and slightly posterior to) fissura *im*; foveae on notogaster each with central mound (central area appearing darker in transmitted light) ..... *Hexachaetoniella* Paschoal
- Notogaster without a seta or its alveolus mesad of fissura *im*, all notogastral setae well posterior to fissura *im*; foveae if present without central mound ..... 8
- 8 Anal valves with 3 pairs of setae ..... 9
- Anal valves with 2 pairs of setae ..... 10
- 9 Notogaster dorsally with complete oval groove or depression inside its margin; iter al setae present on tarsus of leg IV ..... *Darthvaderum* Hunt
- Notogaster dorsally without complete oval groove or depression inside its margin, groove interrupted posteriorly; iter al setae absent from tarsus of leg IV ..... *Pedrocortesella* *enigma* Hunt
- 10 Sensillus club at least partly within bothridium; subcapitulum without a mental tectum ..... *Novazelandiella* Paschoal
- Sensillus club above rim of bothridium; subcapitulum with a mental tectum ..... 11
- 11 In dorsal view, marginal zone of notogaster free of foveae; prodorsum with poorly developed transverse furrow ..... *Labiogena* Hunt
- In dorsal view, foveae extend over entire width of notogaster; prodorsum with well-developed transverse furrow ..... *Pedrocortesella* *nortoni* Hunt

## Family Pheroliodidae Paschoal, 1987

### Character Descriptions

Some characters of relevance to the superfamily Plateremaeoidea, particularly the family *Pedrocortesellidae*, have been discussed by Hunt (1996a). Some characters of special relevance to the Pheroliodidae are treated here.

**Cerotegument.** In many *Pheroliodes*, the larger tubercles of cerotegument covering much of the body and legs have a fluted appearance, not unlike the head of a Phillip's screwdriver (Figs 7E, 9D) and resembling the "stellate" tubercles of *Pedrocortesella*. The smaller tubercles tend to be in the form of more uniformly rounded cushions. The tubercles have a porous appearance at high magnification.

In *Neonooliodes* n.gen. cerotegument occurs as honeycomb-like reticular masses. A survey of cerotegument forms in the Plateremaeoidea may be worthwhile. However, being derived from a secretion,

its precise form within a species may be subject to environmental influences.

**Integumental sculpturing.** In most Pheroliodidae the integument of the prodorsum and notogaster is foveate (Fig. 10F). The reticulate prodorsum of *Octoliodes* (Fig. 17B) and notogaster of *Neonooliodes* n.gen. (Fig. 19A) are diagnostic of these taxa. The presence and nature of cuticular folds and thickenings on the notogaster and ventral plate are useful specific characters.

In *Pheroliodes*, *Hexachaetoniella* and *Labiogena* the border zone of the notogaster is essentially free of microsculptural pitting (Fig. 1A), whereas in *Pedrocortesella* the foveae or other pits occur across the entire dorsal surface.

**Prodorsal enantiophyses.** These are opposing horns or swellings on either side of the transverse furrow on the prodorsum (Fig. 1C) and are diagnostic of the family. The horns are in contact or nearly so. Development of the anterior horn may be less strong than the posterior. Under the stereomicroscope, they are usually best recognised in lateral view.

**Transverse bar anterior to transverse furrow.** The prodorsum anterior to the transverse furrow tends to be rounded in form in the *Pedrocortesellidae* though there may also be a transverse carina. A bar of more dominant form tends to develop in some *Pherolioididae*. This may be of subuniform width with a steep transition towards the rostrum as in *Pheroliodes copiosus* Hunt & Lee, or it may be narrow or essentially missing mesally giving the remaining lateral portions a cheek-like appearance, as in *P. monteithi* n.sp. (Fig. 12B). Its form appears to be a useful species character although the amount of intraspecific variation in this character is not fully understood. The bar may have an accessory spur, and laterally is continuous with the carina between setae *le* and *ro*.

**Seta *ex*.** This seta is present in the *Pherolioididae* but absent in the *Pedrocortesellidae*.

**Form of bothridium.** The posterior part of the bothridial rim is high and may even tend to curve over the bothridial cavity. This contrasts to the depressed or missing posterior wall in many *Pedrocortesella* spp. which relates to its more intimate contact with the notogaster in these species. The strength of the posterolateral carina is a species character.

**Form of sensillus.** In Australian *Pheroliodes* spp. and *Neonooliodes* n.gen., the sensillus has a long petiole which expands very gradually into a narrow terminal lamina, appearing much more delicate than the wider lamina typical of *Pedrocortesella*. The relatively short and less delicate sensillus of *Octoliodes* may be related to the more arboreal tendencies of this species (see Hunt, 1996a,b for discussion on sensillus shape).

**Notogastral setae.** The pherolioidid distribution of setae is regarded as more primitive than *Pedrocortesella* (Hunt, 1996a) as it more closely resembles the nymphal condition. In *Octoliodes*, setae *p2* and *p3* are close together but removed from *p1*, which Paschoal (1987) regarded as a generic character. This condition also

occurs in some *Pheroliodes* spp., however. Insertion of setae in *Octoliodes*, particularly *h1* and *p1*, atop tubercles is a possible generic character, though *Neonooliodes* shows a similar tendency.

**Pedipalp tarsus.** The short apophysis supporting seta *acm* and the barbed seta *l'*, resemble the *Pedrocortesella* condition.

**Epimeral enantiophyses.** The posterolateral corner of epimeron 2 in Australian *Pheroliodes*, and at least some South American species (Baranek, 1984; 1986), tends to have a horn-like process which opposes a similar process on the anterolateral corner of epimeron 3.

**Anal neotrichy.** The usual pherolioidid number of anal setae is three pairs, but in Australian *Pheroliodes* spp. the number varies from three to seven pairs, with asymmetry common. This is apparently a neotrichous condition, a tendency which may be restricted to Australian species. Occasionally there may be four pairs of adanal setae, rather than three.

**Form of the tarsal cluster on legs I and II.** Seta *ft'* is not enclosed in a common rim with solenidia *omega 1* and *omega 2*, unlike the more integrated cluster typical of *Pedrocortesella* (Hunt, 1996a). The rim surrounding the solenidia is often extended distally into a lip or process which overhangs the area of tarsus proximal to the unguinal complex. This is apparently modified in two species with lateral extensions of the lip forming a concavity in the tarsus proximal to the unguinal complex. The lip is possibly restricted to Australian *Pheroliodes*. The position in the tarsal cluster of the chitinised ring surrounding the opening to the cavity containing the undeveloped famulus is a species character. It has a distad-facing position ventral to the solenidia in *Octoliodes*.

**Stalk supporting claws.** The length of the stalk is a species-level character.

### Key to adults of Australian species of Pherolioididae

N.B., for identification under transmitted light the animal should be cleared. Scalps, if present, should be noted and removed to make examination easier)

- 1 Ventral plate with thick honeycomb-like masses of cerotegument (Fig. 19C, 20A) ..... *Neonooliodes ceroplastes* n.sp.
- Cerotegument on ventral plate in form of discrete tubercles ..... 2
- 2 Prodorsum with reticulate pattern anterior to transverse furrow (Fig. 17B); ventral plate heavily folded ..... *Octoliodes robustus* (Hunt & Lee) n.comb.
- Prodorsum away from rostrum foveate or unpatterned (Figs 1C, 4B) ..... 3

- 3 Femur of leg IV with large distoventral blade-like spine (Fig. 15E) ..... *Pheroliodes sicarius* n.sp.
- Femur of leg IV without a large distoventral blade-like spine ..... 4
- 4 Tarsus of leg I with distal concavity (arrow, Fig. 6E)..... 5
- Tarsus of leg I without distal concavity (Fig. 3) ..... 6
- 5 Dorsal surface of leg I tarsus extensively ribbed with cerotegument (Fig. 13B,C) and/or notogaster without strong anteromesal longitudinal furrow (Fig. 14A)..... *Pheroliodes monteithi* n.sp.
- Dorsal surface of leg I tarsus not extensively ribbed with cerotegument and/or notogaster with strong anteromesal longitudinal furrow (Fig. 6A)..... *Pheroliodes concavus* n.sp.
- 6 Notogaster in posterior view heavily folded (just visible under good stereomicroscope) (Fig. 8F) ..... *Pheroliodes lindsayae* n.sp.
- Notogaster in posterior view not heavily folded (Fig. 1E)..... 7
- 7 Setae *lp* transverse, i.e. oriented strongly towards midline (Fig. 16F) ..... *Pheroliodes transversus* n.sp.
- Setae *lp* not markedly transverse, i.e. not oriented strongly towards midline (Fig. 1E) ..... 8
- 8 Notogaster with short anteromesal longitudinal carina (fig. 11E, Hunt & Lee, 1995) ..... *Pheroliodes copiosus* Hunt & Lee
- Notogaster without short anteromesal longitudinal carina but may have furrow (Figs 1A, 10A)..... 9
- 9 Prodorsal bar anterior to transverse furrow with transverse or slightly recurved anterior margin with accessory carina directed anteromesad (Fig. 10B). Lord Howe Island ..... *Pheroliodes lordhowensis* n.sp.
- Prodorsal bar anterior to transverse furrow with procurved anterior margin lacking an accessory carina directed anteromesad (Fig. 11C). Mainland Australia ..... 10
- 10 Opening to cavity containing undeveloped famulus not on distal extremity of rim of tarsal cluster, placed more anteriorly (Fig. 3B) ..... *Pheroliodes springthorpei* n.sp.
- Opening to cavity containing undeveloped famulus on distal extremity of rim of tarsal cluster (Fig. 3B) ..... *Pheroliodes barringtonensis* n.sp.

### *Pheroliodes* Grandjean, 1931

*Pheroliodes* Grandjean, 1931: 249; 1964: 383.—Covarrubias, 1968: 692.—Fernandez, 1987: 186.—Paschoal, 1987: 359; 1989b: 197.—Balogh & Balogh, 1992: 47.—Woas, 1992: 144–146.—Hunt & Lee, 1995: 235.  
*Phereliodes* (sic): Balogh, 1972: 58.—Balogh & Balogh, 1988: 92.  
*Pedrocortesia* Hammer, 1958: 40.—Ryabinin, 1986: 341–42 (synonymised by P. Balogh, 1985: 51)

**Type species.** *Cymbaeremaeus wehncke* Willmann, 1930 by original designation.

**Diagnosis.** Prodorsum with deep transverse furrow carrying enantiophyses, foveate or unpatterned anterior to transverse furrow, not reticulate; *ex* present; sensillus in Australian species with long petiole expanding gradually into lamina; notogaster continuously convex, without depressed area inside margin; notogaster foveate;

reticulate centrally, without foveae around its margins; ventral plate and legs not reticulate; 3–7 pairs of anal setae; distal lip of rim of tarsal cluster often present, distal recess or concavity, if present, roofed by lip; tarsus of leg IV without iterate setae.

### Description

Medium to large sized plateremaeoid mites (500–1000  $\mu\text{m}$ ); integument with fluted tubercles of cerotegument; notogaster with or without exuvial scalps; prodorsum with deep transverse furrow carrying enantiophyses (opposing horns); prodorsum anterior to transverse furrow with a transverse bar continuous with carina between setae *le* and *ro*; prodorsum foveate or unpatterned, not reticulate away from rostrum; seta *ex* present; seta *in* small and arising from small apophysis; bothridium with strong or weak posterolateral carina; bothridium abutting notogaster but posterior wall not depressed; sensillus a flattened (though in Australian species less broad than *Pedrocortesella*), covered with tubercles; notogaster convex, not concave intramarginally, often with longitudinal anteromesal furrow or carina; foveate centrally and with foveae-free border; 5 pairs of notogastral setae, setae *p2* and *p3* situated low on the posterior flank ventrolateral to setae *p1*; *lp* situated close to fissura *ip*; *lm* (*r3*) absent; pedipalp tarsus with short apophysis supporting seta *acm*, seta *l''* with barbs; epimeral chaetotaxy 3:1:3:3; ventral plate without honey-comb reticulation pattern, 7 pairs of genital setae (10 in *P. inca* Fernandez *et al.*); 1 aggenital seta lateral to each genital valve; 3–7 anal setae on either valve, sometimes asymmetrical in number, 3–4 adanal setae, *ad1* usually lateral to posterior 20% of anal valve; legs without conspicuous reticulation pattern of cerotegument; *ft''* of tarsus I not enclosed in same rim as solenidia; famulus usually undeveloped and enclosed within cavity; claw stalk long or short; tarsus of leg IV without iterate setae.

### Descriptions of *Pheroliodes* species

#### *Pheroliodes springthorpei* n.sp.

Figs 1, 2, 3A,B

**Type material.** New South Wales: HOLOTYPE adult, AM KS46603 SEM stub no. S/128 (ill.), Mosman, Parriwi Park, ca 33°50'S 151°15'E, berlesate litter and soil, beneath *Casuarina*, G.S. Hunt, 16 June 1992. PARATYPE adults, AM KS46604 SEM stub no. S/080 (ill.), West Head, Ku-ring-gai Chase National Park, 33°35'S 151°18'E, dry sclerophyll, *Casuarina* dominant, berlesate leaf litter, G.S. Hunt, 1 May 1992, 4 adults; AM KS46605 SEM stub no. S/088-02, same data, 2 adults (together on stub).

**Diagnosis.** Transverse bar in front of transverse furrow narrow mesally with procurved anterior edge; notogaster without anteromesal longitudinal carina, with weak

anteromesal longitudinal furrow, posteriorly not heavily folded; setae *lp* not oriented strongly towards midline; 3–4 pairs anal setae; dorsal surface of leg I tarsus not extensively ribbed with cerotegument; tarsus of leg I without distal concavity; rim around tarsal cluster not produced into a strong distal lip overhanging distal part of tarsus; sclerotised ring surrounding opening of cavity containing undeveloped famulus on distal extremity of rim of tarsal cluster; femur of leg IV without a large distoventral blade-like spine; stalk short.

### Description

**ADULT:** Body light brown, length 570  $\mu\text{m}$ , 650  $\mu\text{m}$ . **Cerotegument:** body and legs covered in closely spaced tubercles, many fluted to resemble a Phillips screwdriver head (Fig. 2D). Setae *ro* and *le*, notogastral setae and some leg setae with dense pile of cerotegument (Fig. 1E). **Prodorsum:** transverse furrow with a smaller mesal transverse furrow anterior to it; transverse bar in front of transverse furrow narrow mesally (in comparison with *P. copiosus* Hunt & Lee (1995, fig. 7D)) with procurved anterior edge but no accessory carina directed anteromesad (Fig. 1C); area immediately anterior to bar foveate; setae *le* lateral, distance between them about 0.8 distance between *ro*, *ro* ventrolateral; pedotectal tooth smooth, strongly curved antierad; bothridium abutting notogaster (Fig. 1D), rim subcircular, anterolateral rim much lower than posterolateral rim, posterolateral carina strong; sensillus long, expanding gradually to blade from slightly above bothridial rim, tuberculate from bothridial rim (Fig. 1D); *in* arising from apophysis at edge of dorsosejugal suture and separated by about 0.5 bothridial diameter from bothridial wall, small, acute, proximally with heavy cerotegument (Fig. 1D); *ex* anterolateral to base of bothridium, small, largely covered with cerotegument granules; posterior margin of prodorsum between bothridia smooth and straight. **Notogaster:** exuvial scalps not seen. Ratio length:breadth 480:370; centrally foveate, smooth around borders (Fig. 1A) except for dense tubercles of cerotegument. Fissura *ia* subparallel-oblique and *im* and *ip* oblique to sagittal plane. Very weak anteromesal furrow, no anteromesal carina, posteriorly not heavily folded; posterior margin convex with a small elevation between setae *hl* when viewed dorsally, with small vertical carina between setae *p1* and a shallow transverse furrow between *hl* and *p1* when viewed posteriorly (Fig. 1E). Setae *hl* moderately long, close together and inserted near posterior margin; setae *lp* inserted on posterior margin posteromesad of *ip*, not strongly curved mesad; *p1*, *p2* and *p3* situated low on posterior flank, in decreasing size order. **Gnathosoma:** mentum with strong transverse carina immediately anterior to setae *h* and a mesal carina at labiogenal suture; rutella posteriorly with slight concave flexure (Fig. 2B); length of apophysis supporting pedipalp tarsal seta *acm* <0.5 seta length, solenidion reaching above base of *acm*, seta *l''* strongly barbed and set ventrally on anti-axial surface (Fig. 2C). **Genitoanal region:** ventral plate foveate posterolaterally. Chaetotaxy



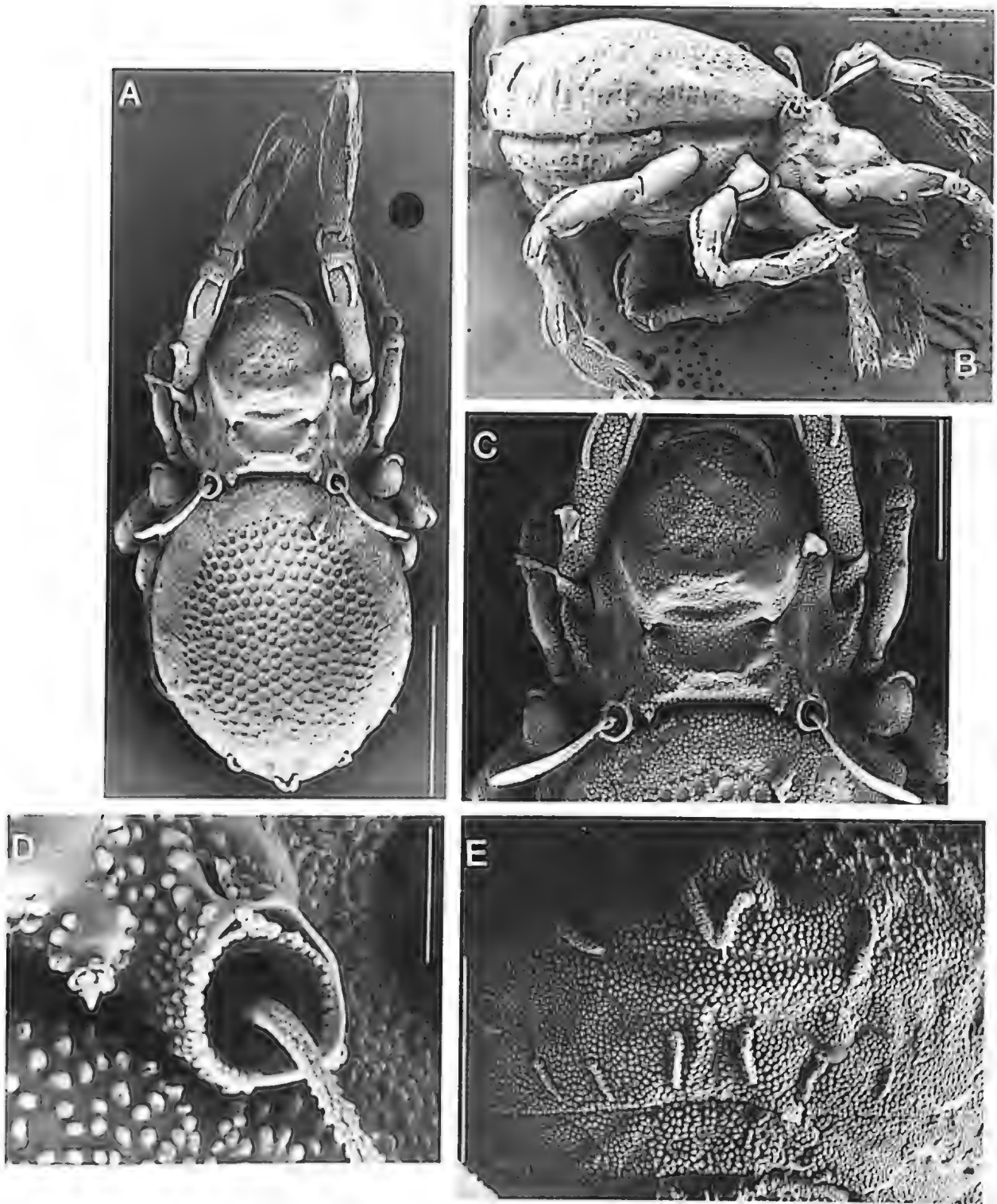


Fig. 1. *Pheroliodes springthorpei* n.sp. A,B, body, dorsal and lateral; C, prodorsum, dorsal; D, bothridium and seta *in*; E, notogaster, posterior. Scale bars: A,B = 200  $\mu$ m; C,E = 100  $\mu$ m; D = 20  $\mu$ m. A,C-E = Ku-ring-gai Chase; B = Mosman

7:1:3-4:3; setae *gl* and *g7* set in marginal notches in inner corners of genital valve, other setae in straight file close to lip of valve (Fig. 2D); seta *ag* close to lateral margin of valve (Fig. 2D); anal setae often asymmetrical in number; insertion of seta *ad1* at level of posterior margin of anal valve or slightly anterior to it, *ad2* at

about 0.5 valve length, *ad3* adjacent to proximal 40% of valve, subequal to *ad2* in separation from anal valve (Fig. 2E). *Leg I*. Smooth except for cerotegument tubercles (Fig. 3A). Apophysis on tibia overhanging about 0.25 tarsus, dorsal surface of tarsus forming a smoothly sloping crest terminating in tarsal cluster (Fig.

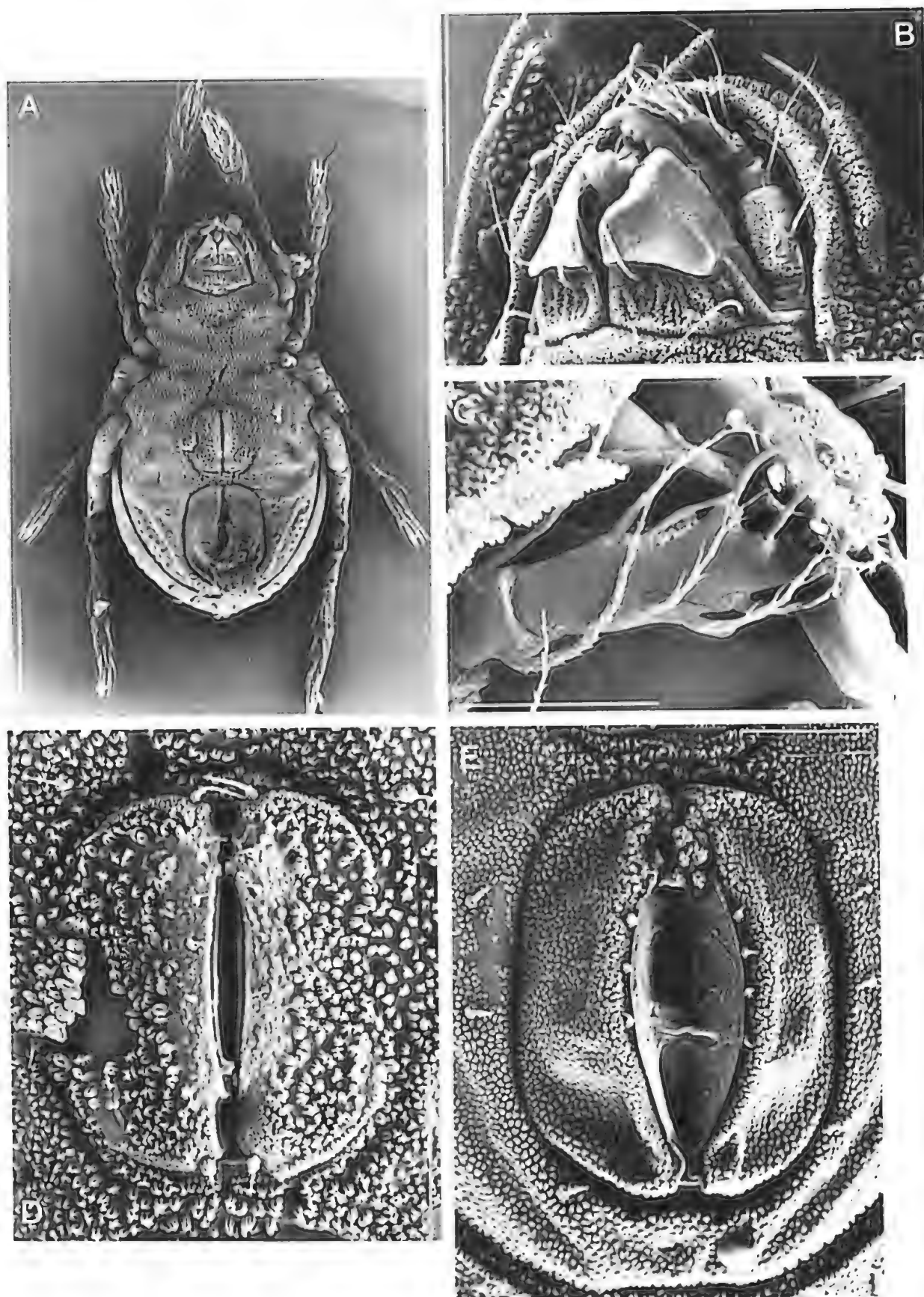


Fig. 2. *Pheroliodes springthorpei* n.sp. A, body, ventral; B, subcapitulum, ventrolateral; C, pedipalp tarsus, antiaxial; D, genital valves; E, anal valves. Scale bars: A = 200 µm; B,D,E = 50 µm; C = 20 µm.

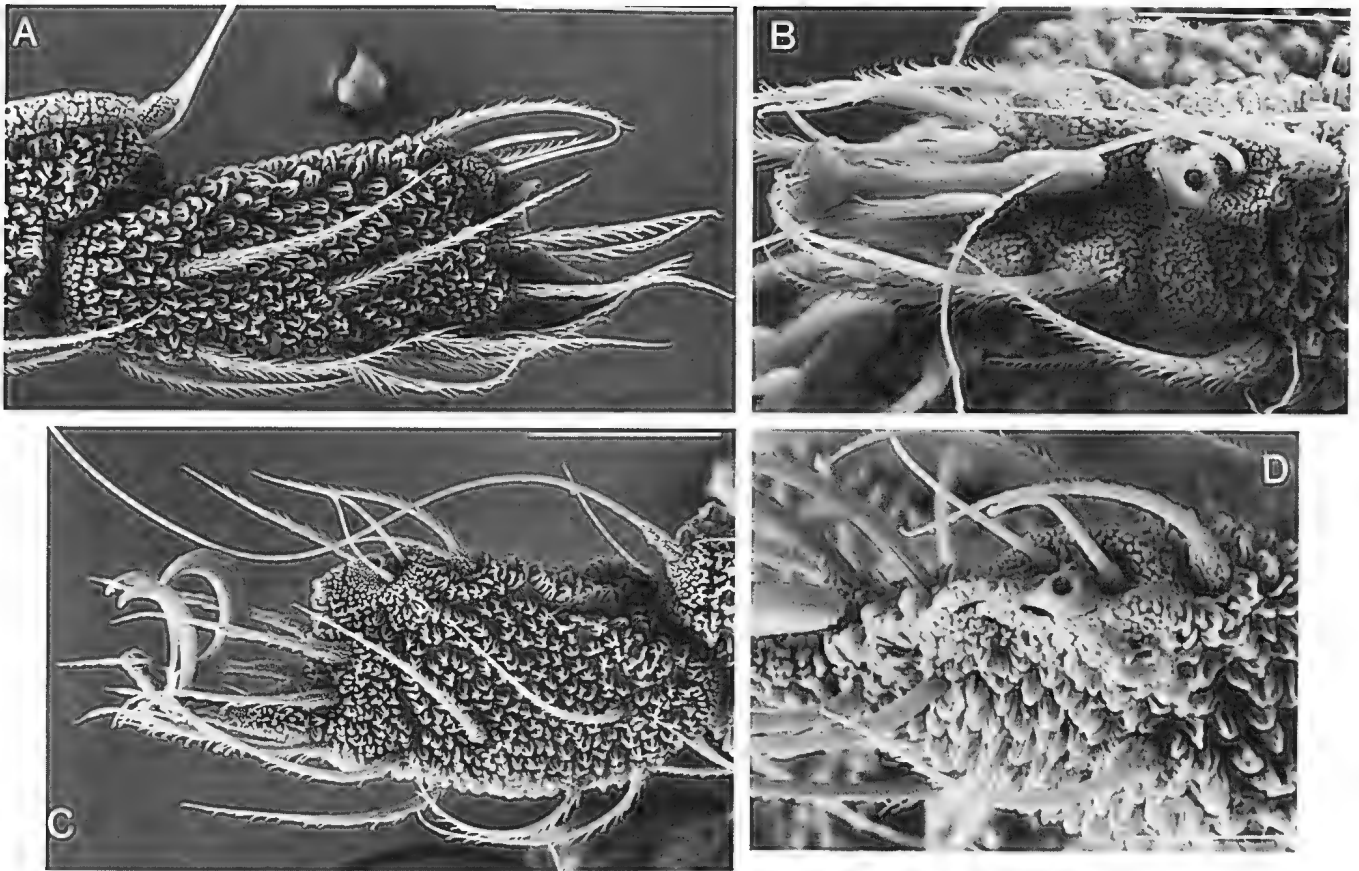


Fig. 3. *Pheroliodes springthorpei* n.sp. leg I tarsus: A, antiaxial; B, distal region, dorsal. *Pheroliodes lindsayae* n.sp. leg I tarsus: C, antiaxial; D, distal region, dorsal. Scale bars: A,C = 50  $\mu$ m; B,D = 20  $\mu$ m. A = Mosman; B = Ku-ring-gai Chase.

3A), seta *fi*" situated at highest point and arching gently distad, *omega* 1 and 2 inserted at more ventral level, sclerotised ring surrounding opening of cavity containing undeveloped famulus at distodorsal extremity of tarsus paraxial to *omega* 2 (Fig. 3B), seta *tc*" inserted directly ventral to *omega* 2; setal barbs long; stalk short (Fig. 3A). Leg II tarsal cluster rim with strong distal lip similar to *P. copiosus*.

**Etymology.** The specific epithet acknowledges the help Roger Springthorpe has given me for several years in the preparation of illustrations for publication.

**Distribution.** New South Wales: Sydney area.

#### *Pheroliodes barringtonensis* n.sp.

Figs 4, 5

**Type material.** New South Wales: HOLOTYPE adult. AM KS46596 SEM stub no. S/424 Gloucester River, Barrington Tops National Park, 32°04'S 151°41'E, rainforest leaf litter, ANIC berlesate 750, T. Weir and A. Calder, 12–14 November 1981. PARATYPE adults. AM KS46597 SEM stub no. S/202 (ill.), same data as holotype, 1 adult; AM KS46598 SEM stub no. S/425 (ill.), Allyn River, Chichester State Forest, 32°12'S

151°26'E, rainforest leaf litter, ANIC berlesate 747, T. Weir and A. Calder, 10–11 November 1981, 2 adults; AM KS46599 SEM stub no. S/105 (ill.), same data, 1 adult; AM KS46600 SEM stub no. S/106 (ill.), same locality and collector data, ANIC berlesate 748, 1 adult.

**Diagnosis.** Transverse bar anterior to transverse furrow excavated mesally reducing bar to essentially a pair of lateral "cheeks"; notogaster without short anteromesal longitudinal carina or groove, posteriorly not heavily folded; setae *lp* not oriented strongly towards midline; 3–5 pairs anal setae; dorsal surface of leg I tarsus not extensively ribbed with cerotegument and lacking distal concavity; rim around tarsal cluster produced into a distal lip or process which strongly overhangs distal part of tarsus; alveolus of seta *epsilon* not on distal extremity of rim of tarsal cluster; femur of leg IV without large distoventral blade-like spine; stalk long.

#### Description

**ADULT:** Differs from *P. springthorpei* in the following: body longer, length 820  $\mu$ m. Setae *ro* and *le*, notogastral setae and leg setae without dense pile of cerotegument. **Prodorsum:** transverse furrow with only a suggestion of a smaller mesal transverse furrow anterior to it; transverse

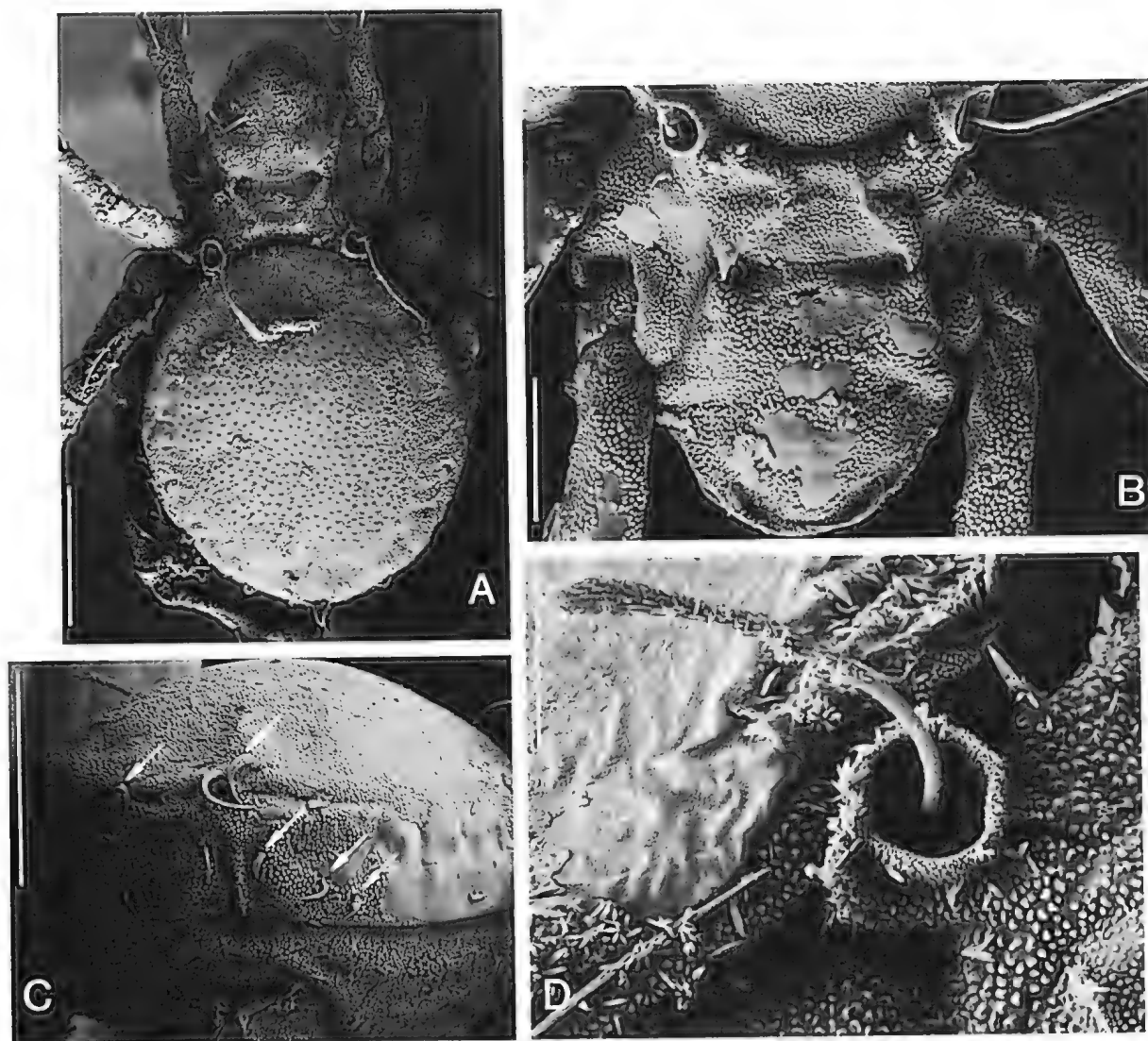


Fig. 4. *Pheroliodes barringtonensis* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, notogaster, posterior, arrows left to right label setae *lp* (left side) and setae *hl* (right side), *p1*, *p2* and *p3*; D, bothridium, sensillus, setae *in* and *ex*. Scale bars: A–C = 200  $\mu$ m; D = 50  $\mu$ m. A–D = Allyn River.

bar anterior to transverse furrow excavated mesally reducing bar to essentially a pair of lateral “cheeks” (Fig. 4B), no area of prodorsum obviously foveate though some dimpling of integument occurs; setae *le* dorsolateral, distance between them about 0.75 distance between *ro*; sensillus blade narrower; margin of prodorsum between bothridia gently curved. *Notogaster*: ratio length:breadth 530:470; foveae more widely spaced (Fig. 4A); fissura *ia*, *im* and *ip* oblique to sagittal plane. Anteromesal groove absent; setae *hl* short, tending to be twisted to one side; *Gnathosoma*: mentum without strong transverse carina (Fig. 4B). Pedipalp not studied. *Genitoanal region*: ventral plate not obviously foveate but dimples probably equivalent (Fig. 4A,C); genital valve with small longitudinal foveae. Genitoanal chaetotaxy 7:1:4–5:3–4; anal setae often asymmetrical in number; insertion of seta *ad1* at level of posterior margin of anal valve or slightly anterior to it, *ad2* adjacent to posterior 40% of valve, *ad3* adjacent to proximal 40% of valve, *ad4* if

present adjacent to anterior 25% of valve (Fig. 4C). *Leg I*. Femur 2 with short mid-ventral keel. Tarsus with dorsal antiaxial carina (Fig. 5D) continuous with rim of tarsal cluster; rim of tarsal cluster projecting distad in lip similar to *P. copiosus* (Hunt & Lee, 1995, fig. 16G); *omega 1* and 2 inserted at about same dorsal level as *ft*, sclerotised ring surrounding opening of cavity containing undeveloped famulus not at distodorsal extremity of tarsal cluster rim, located paraxially between *omega 1* and 2 (Fig. 5D,F), seta *tc* inserted ventral and slightly distal to *omega 2*; stalk moderately long (Fig. 5D). *Leg II* tarsal cluster rim with very long distal lip (Fig. 5E).

**Etymology.** The specific epithet refers to Barrington Tops, the general area in which the species has been collected.

**Distribution.** New South Wales: Barrington Tops area, near Newcastle.



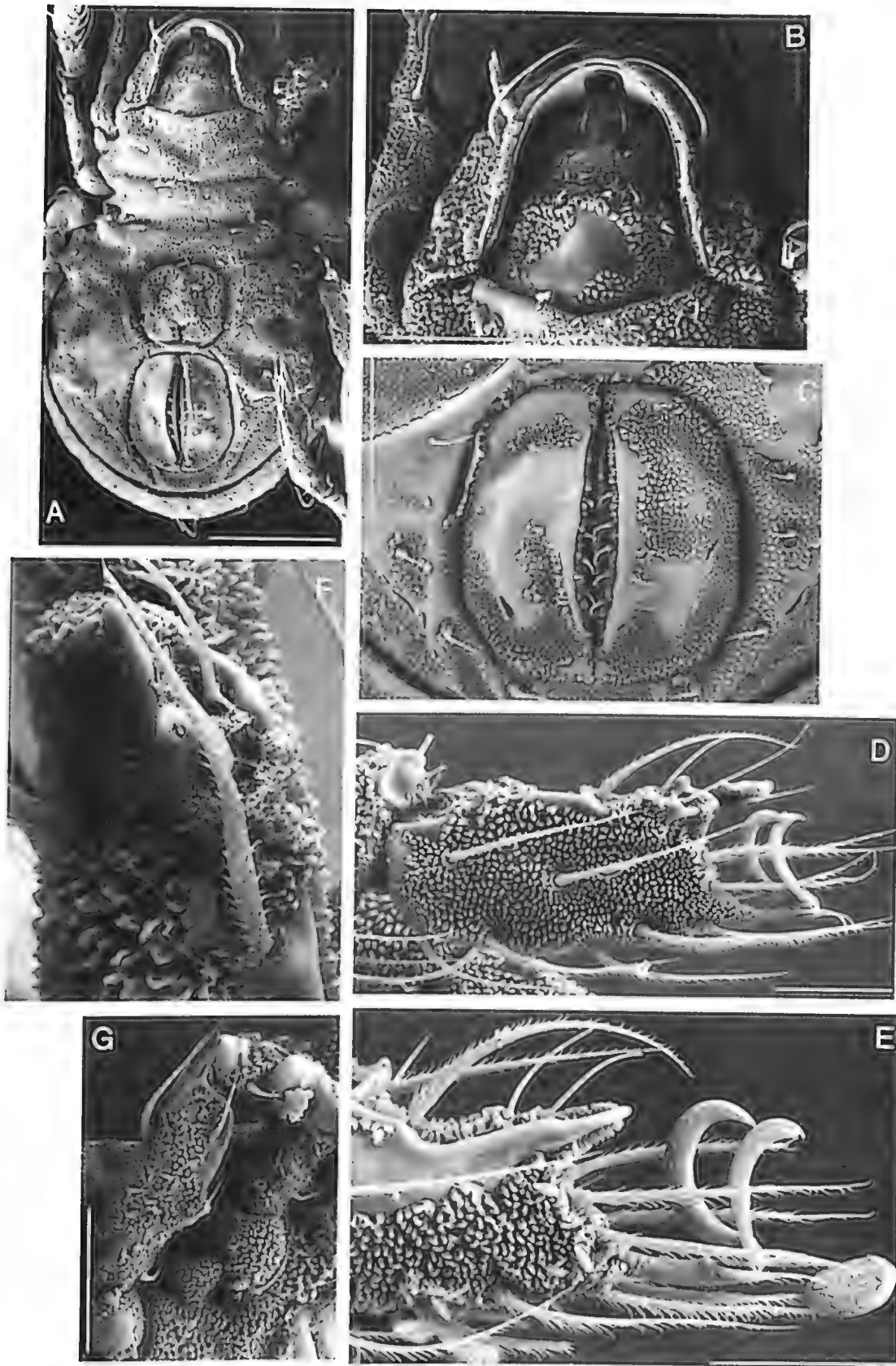


Fig. 5. *Pheroliodes barringtonensis* n.sp. A, body, ventral; B, subcapitulum; C, anal valves; D, leg I tarsus, antiaxial; E, leg II tarsal cluster, antiaxial; F, tarsus I detail, dorsodistal (proximal end at bottom); G, pedotectal tooth *p* and femur leg II. Scale bars: A = 200  $\mu$ m; B,C,G = 100  $\mu$ m; D,E = 50  $\mu$ m; F = 20  $\mu$ m. A,B,D-F = Allyn River; C = Gloucester River.

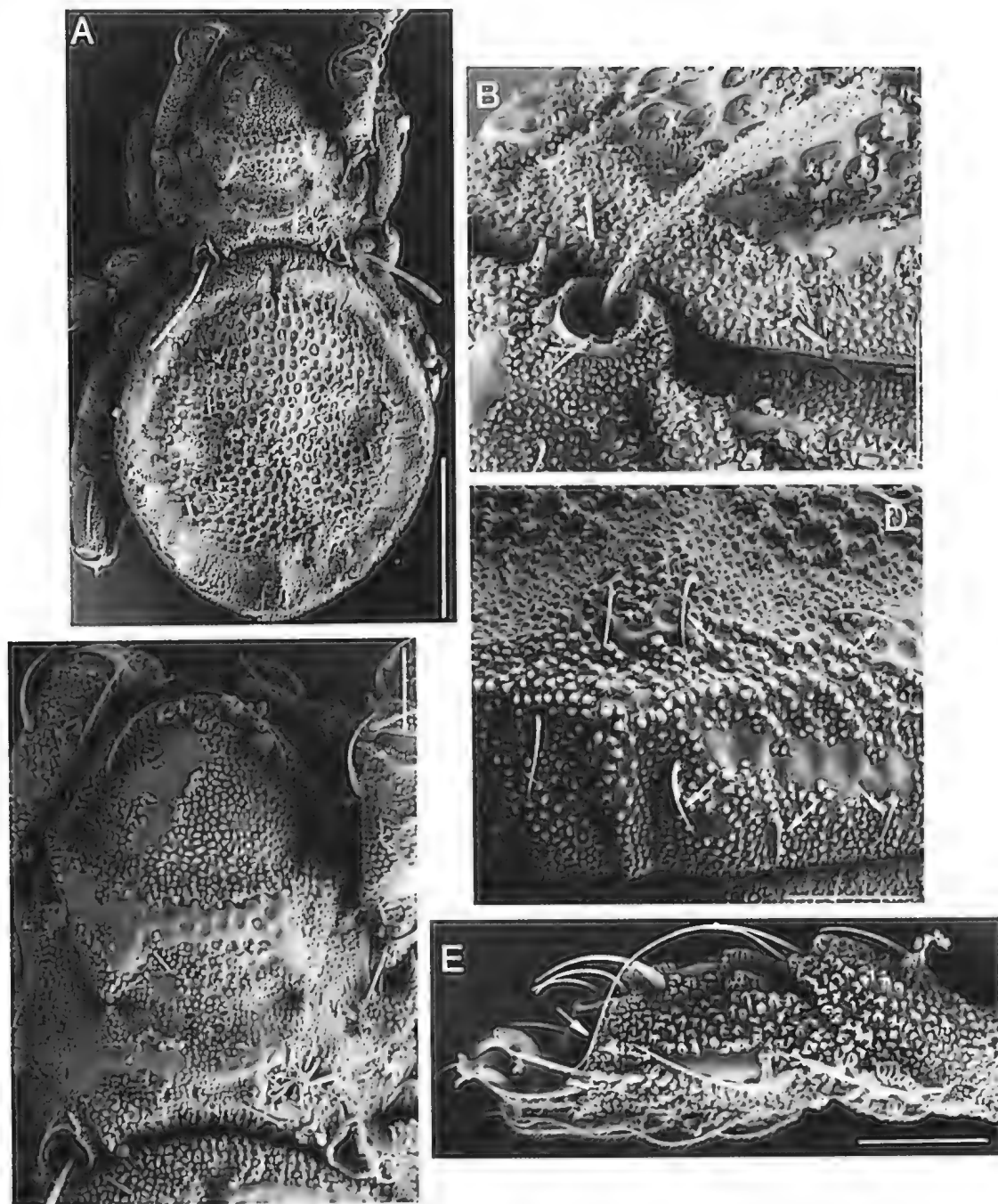


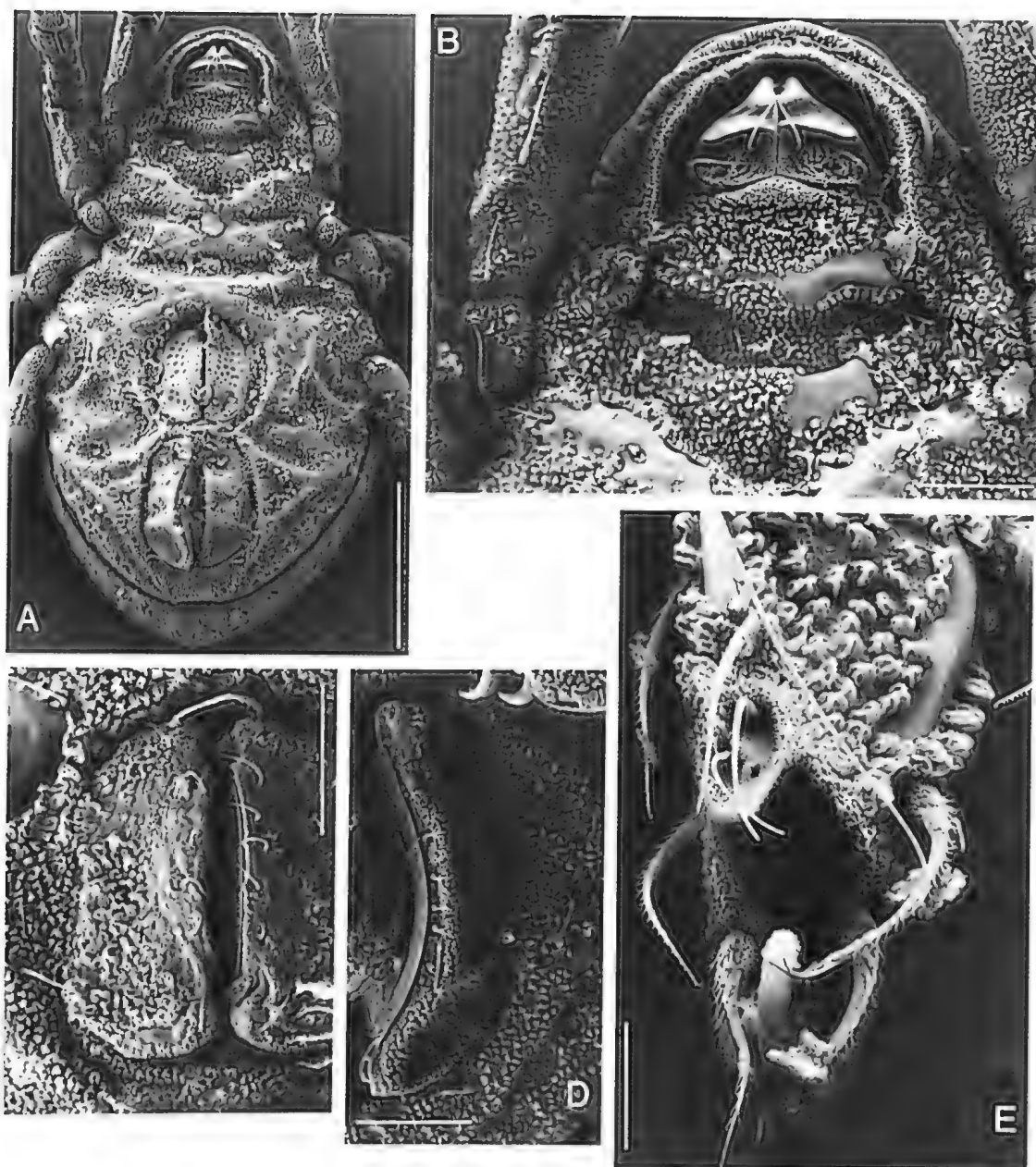
Fig. 6. *Pheroliodes concavus* n.sp. A, body, dorsal; B, bothridium, sensilli and setae *in* and *ex*, lateral; C, prodorsum, dorsal; D, notogaster, part of posterior region, upper arrows left to right label setae *hl* and *lp*; lower arrows left to right label *p1*, *p2*, and *p3*; E, leg I tibia (distal) and tarsus, antiaxial, arrow to distal concavity. Scale bars: A = 200  $\mu$ m; B–E = 50  $\mu$ m.

*Pheroliodes concavus* n.sp.

Figs 6, 7

**Type material.** New South Wales: HOLOTYPE adult. AM KS43826, Kiwarra State Forest, 31°58'S 152°26'E, berlesate of litter in central burning area, Forestry Commission, BLK/800 C/A7, A10, A14, A15 pooled, 1991. PARATYPE adults. AM KS46619 SEM stub no. S/113 (ill.), same data as holotype, 4 adults; AM KS43827, same data, 1 adult.

**Diagnosis.** Transverse bar in front of transverse furrow narrow mesally with procurved anterior edge; notogaster without short anteromesal longitudinal carina but with strong longitudinal furrow, posteriorly not heavily folded; setae *lp* not oriented strongly towards midline; 4–5 pairs anal setae; dorsal surface of leg I tarsus moderately ribbed with cerotegument; tarsus of leg I with distal concavity; rim around tarsal cluster produced into a distal lip or process which strongly overhangs distal part of tarsus; sclerotised



**Fig. 7.** *Pheroliodes concavus* n.sp. A, body, ventral; B, subcapitulum; C, genital valves; D, anal valve; E, leg I tarsus (distal), distodorsal. Scale bars: A = 200  $\mu\text{m}$ ; B–D = 50  $\mu\text{m}$ ; E = 20  $\mu\text{m}$ .

ring surrounding opening of cavity containing undeveloped famulus not on distal extremity of rim of tarsal cluster; femur of leg IV without large distoventral blade-like spine; stalk short.

### Description

**ADULT:** Differs from *P. springthorpei* in the following: body longer, length 770  $\mu\text{m}$ . Setae *ro* and *le*, notogastral setae and leg setae with slight coating of cerotegument. **Prodorsum:** transverse furrow without smaller mesal transverse furrow anterior to it; transverse bar strongly foveate; setae *le* dorsolateral, very strong carina

between *le* and *ro*; bothridial rim slightly depressed posteriorly, more so anterolaterally; posterior margin of prodorsum between bothridia curved. **Notogaster:** ratio length:breadth 500:440; more flattened; central foveae very pronounced, some smaller foveae visible on lateral margins (Fig. 6A); fissura *ia* and *ip* oblique, and *im* subperpendicular to sagittal plane; notogaster with strong anteromesal groove (Fig. 6A). **Gnathosoma:** mentum with setae *h* arising from strong transverse carina; rutella posteriorly with strong concave flexure (Fig. 7B); pedipalp not studied. **Genitoanal region:** ventral plate more generally foveate, with strong triangular cuticular thickening adjacent to anal valves continuous with strong thickening flanking genital



valves; genital valves foveate (Fig. 7C); chaetotaxy 7:1:5:3. *Leg I*. Tarsus with strong dorsolateral carina on each side (Fig. 7E), and with very strong distal concavity presumably to receive retracted claw complex; solenidia *omega 1* and *2* opening to cavity containing famulus enclosed in saucer-like rim, the distal lip of which overhangs distal concavity in tarsus (Fig. 7E); seta *tc''* inserted distal to *omega 2*; stalk short (Fig. 6E).

**Etymology.** The specific epithet is Latin for "hollowed" and refers to the distal concavity in the tarsus of leg I.

**Distribution.** New South Wales: Type locality near Kempsey.

*Pheroliodes lindsayae* n.sp.

Figs 3C,D, 8, 9

**Type material.** Tasmania: HOLOTYPE adult. ANIC, Mount Michael, 41°10'S 148°00'E, pyrethrum knock-down from tree, R. Coy, 28 November 1989. PARATYPE adults. AM KS46613 SEM stub no. S/270 (ill.), same data as holotype, 4 adults; AM KS43824, same data, 3 adults; ANIC, same data, 3 adults; CNC, same data, 3 adults; FMNH, same data, 2 adults; QM, same data, 2 adults.

**Other material examined.** Tasmania: AM KS46614 SEM stub no. S/315 (ill.), Big Sassy Creek, 42°08'S 147°54'E, 400 m, rainforest site 1, moss on tree, J. Diggle and H. Mitchell, 17 May 1989, 1 adult; AM KS46615 SEM stub no. S/316, same data, 1 adult; AM KS46616 SEM stub no. S/321, Big Sassy Creek, 42°08'S 147°54'E, 400 m, rainforest site 1, tree fern sample, H. Mitchell, 17 May 1989, 3 adults; AM KS46617 SEM stub no. S/326 (ill.), Bradshaws Road (Anthony Road), Mount Murchison, 41°49'S 145°37'E, 840 m, rainforest site 2, moss on rocks, P. Greenslade, 21 April 1989, 1 adult; AM KS46618, SEM stub no. S/322 (ill.), Mount Mangana, Bruny Island, site 2, 43°22'S 147°17'E, 540 m, moss at base of tree, J. Diggle, P. Greenslade, 4 October 1989, 4 adults; ANIC, Mount Michael, 41°10'S 148°00'E, in moss, A. Trumbull-Ward, 11 June 1990, 2 adults; AM KS43825, Mount Victoria, 41°20'S 147°49'E, 900 m, pyrethrum knockdown from trees, H. Mitchell and R. Coy, 25 November 1989, 4 adults; ANIC, same data, 18 adults; ANIC, Rivaux Creek, ca 43°10'S 146°39'E, rainforest litter, P. Greenslade, 20 December 1988, 1 adult; ANIC, Sandspit River, 42°42'S 147°52'E, rainforest leaf litter, P. Greenslade, 22 May 1989, 5 adults.

**Diagnosis.** Transverse bar in front of transverse furrow with gradually sloping transition towards rostrum; notogaster with marked anteromesal grooving, posteriorly heavily folded; setae *lp* oriented strongly towards midline; 5–7 pairs anal setae; dorsal surface of leg I tarsus not extensively ribbed with cerotegument; tarsus of leg I without distal concavity; rim around

tarsal cluster not produced into a distal process which strongly overhangs distal part of tarsus; sclerotised ring surrounding opening of cavity containing undeveloped famulus not on distal extremity of rim of tarsal cluster; femur of leg IV without large distoventral blade-like spine; stalk medium.

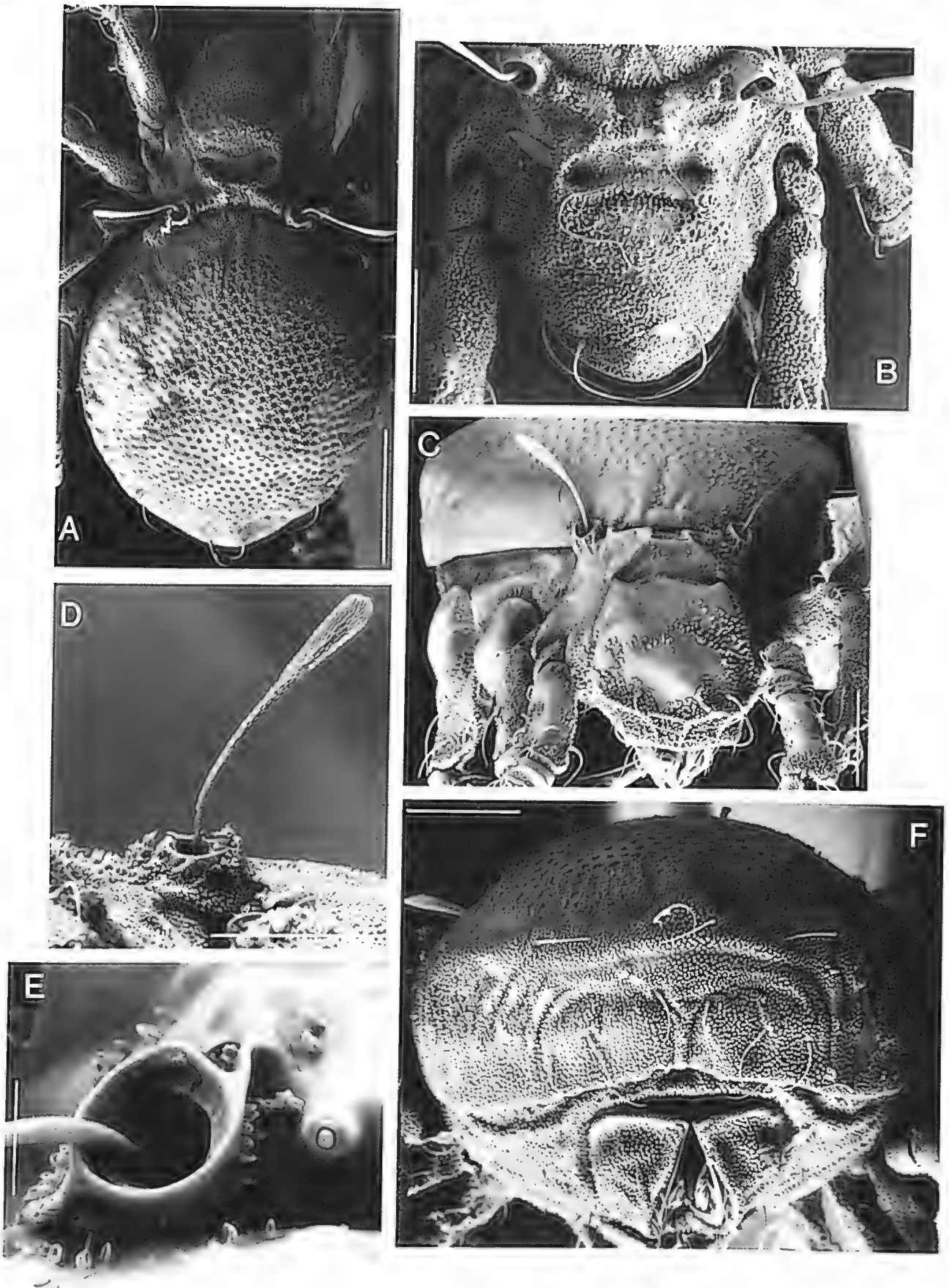
## Description

**ADULT:** Differs from *P. springthorpei* in the following: larger, length 790 µm, 800 µm, 850 µm; body and leg setae without dense cerotegument (Fig. 8B,F). *Prodorsum:* transverse bar anterior to transverse furrow depressed mesally (Fig. 8C) and slopes gradually towards rostrum in comparison with *P. copiosus* (Hunt & Lee, 1995, fig. 11D); bar sparsely foveate; strong carina between *le* and *ro*; sensillus not expanding as quickly and terminating in smaller lamina; posterior margin of prodorsum more curved and puckered. *Notogaster:* ratio length:breadth 630:500; foveae more widely separated (Fig. 8A,C); fissura *ia* subparallel to sagittal plane; very strong anteromesal grooves; posterior flank of notogaster heavily folded in characteristic pattern, prominent carina between setae *p1* (Fig. 8F); setae *lp* curved strongly mesad; *p1*, *p2* and *p3* long. *Gnathosoma:* mentum without transverse carina immediately anterior to setae *h* (Fig. 9B). *Genitoanal region:* chaetotaxy 7:1:5–7:3–4; setae *g7* not set in marginal notches in inner posterior corner of genital valve; adanal setae long, *ad1* postanal (Fig. 9E); ventral plate with distinct groove lateral to separation of anal and genital plates (Fig. 9A). *Leg I.* Solenidia *omega 1* and *2* inserted at same dorsal level as *ft''*; sclerotised ring surrounding opening of cavity containing undeveloped famulus somewhat proximal to distodorsal extremity (Fig. 3D), seta *tc''* inserted somewhat distad to *omega 2*; setal barbs shorter; stalk moderately long (Fig. 3C). *Leg II* tarsal cluster rim with weak distal lip.

**Variation.** One specimen from Big Sassy Creek lacked a supplementary transverse furrow anterior to the deep transverse furrow.

**Etymology.** The specific epithet acknowledges the help that Sue Lindsay has given me in scanning electron microscopy.

**Distribution.** Tasmania.



**Fig. 8.** *Pheroliodes lindsayae* n.sp. A, body, dorsal; B,C, prodorsum, dorsal and frontal; D, bothridium, sensillus and seta *in*, lateral; E, bothridium and seta *in*, dorsal; F, body, posterior. Scale bars: A = 200  $\mu$ m; B,C,D,F = 100  $\mu$ m; E = 20  $\mu$ m. A,D,F = Bradshaws Road; B = Mount Mangana; C,E = Mount Michael.

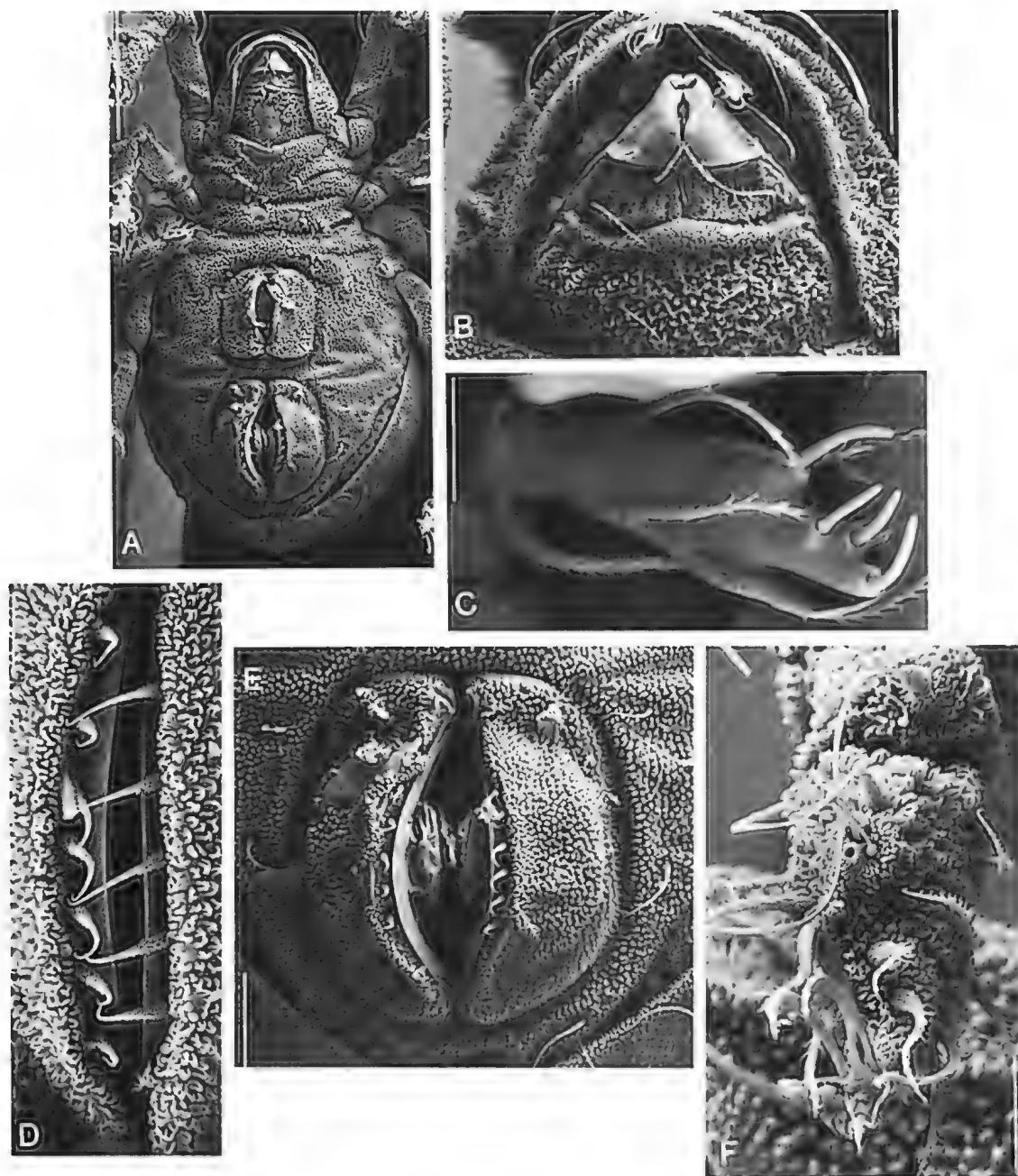


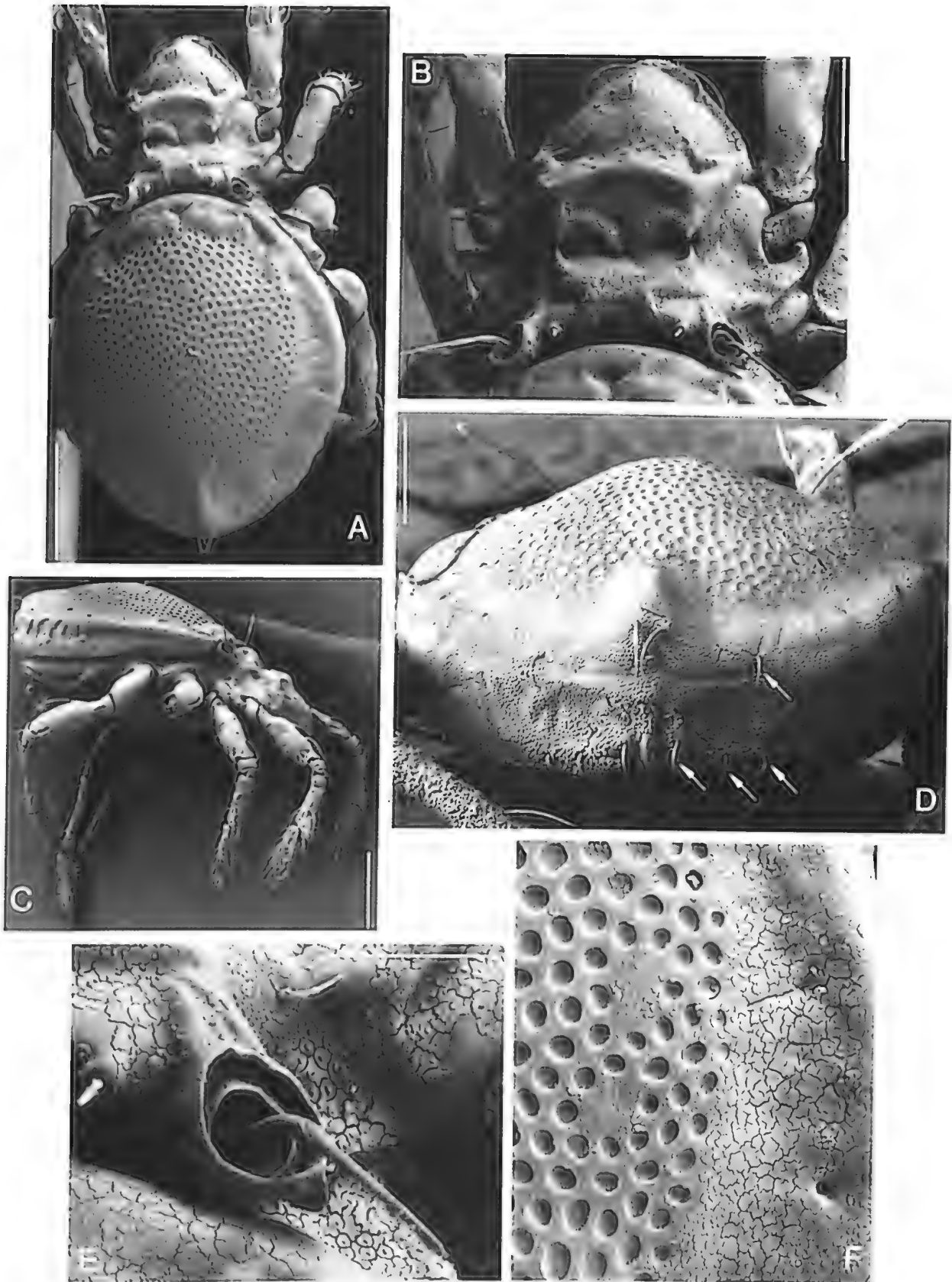
Fig. 9. *Pheroliodes lindsayae* n.sp. A, body, ventral; B, subcapitulum; C, pedipalp tarsus, antiaxial; D, anal setae; E, anal valves; F, leg I tarsus, distodorsal. Scale bars: A = 200  $\mu$ m; B,E = 50  $\mu$ m; D,F = 25  $\mu$ m; C = 10  $\mu$ m. A,E,F = Bradshaws Road; D = Mount Mangana; B = Big Sassy Creek; C = Mount Michael.

*Pheroliodes lordhowensis* n.sp.

Figs 10, 11

**Type material.** Lord Howe Island: HOLOTYPE adult. QM, base of Mount Eliza, 31°31'S 159°03'E, 10 m, volcanic soil, QM berlesate 131, G.B. Monteith, 7 November 1979. PARATYPE adults. AM KS46601 SEM stub no. S/234 (ill.), same data as holotype, 3 adults. QM S20135, SEM stub no. S/055 (ill.), Mount Eliza summit, 31°31'S 159°03'E, 150 m, volcanic soil, QM berlesate 154, G.B. Monteith, 19 November 1979, 1 adult.

**Diagnosis.** Transverse bar in front of transverse furrow narrow mesally, carrying accessory carina directed anteromesad; notogaster without short anteromesal longitudinal carina, with strong anteromesal furrow, posteriorly not heavily folded; setae *lp* not oriented strongly towards midline; 4 pairs anal setae; dorsal surface of leg I tarsus not extensively ribbed with cerotegument; tarsus of leg I without distal concavity; rim around tarsal cluster produced into a distal process, robust in lateral view, which strongly overhangs distal part of tarsus; sclerotised ring surrounding opening of cavity containing undeveloped famulus not on distal



**Fig. 10.** *Pheroliodes lordhowensis* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, body, lateral; D, notogaster, posterior, arrows left to right label setae *p1*, *p2*, *lp* and *p3* (conspicuous *h1* not arrowed); E, bothridium, setae *in* and *ex*, sensillus broken, cerotegument removed, cracking an artefact; F, notogastral foveae, fissura *im* and *gla*, cracking an artefact. Scale bars: A,C = 200 µm; B,D = 100 µm; E,F = 50 µm.



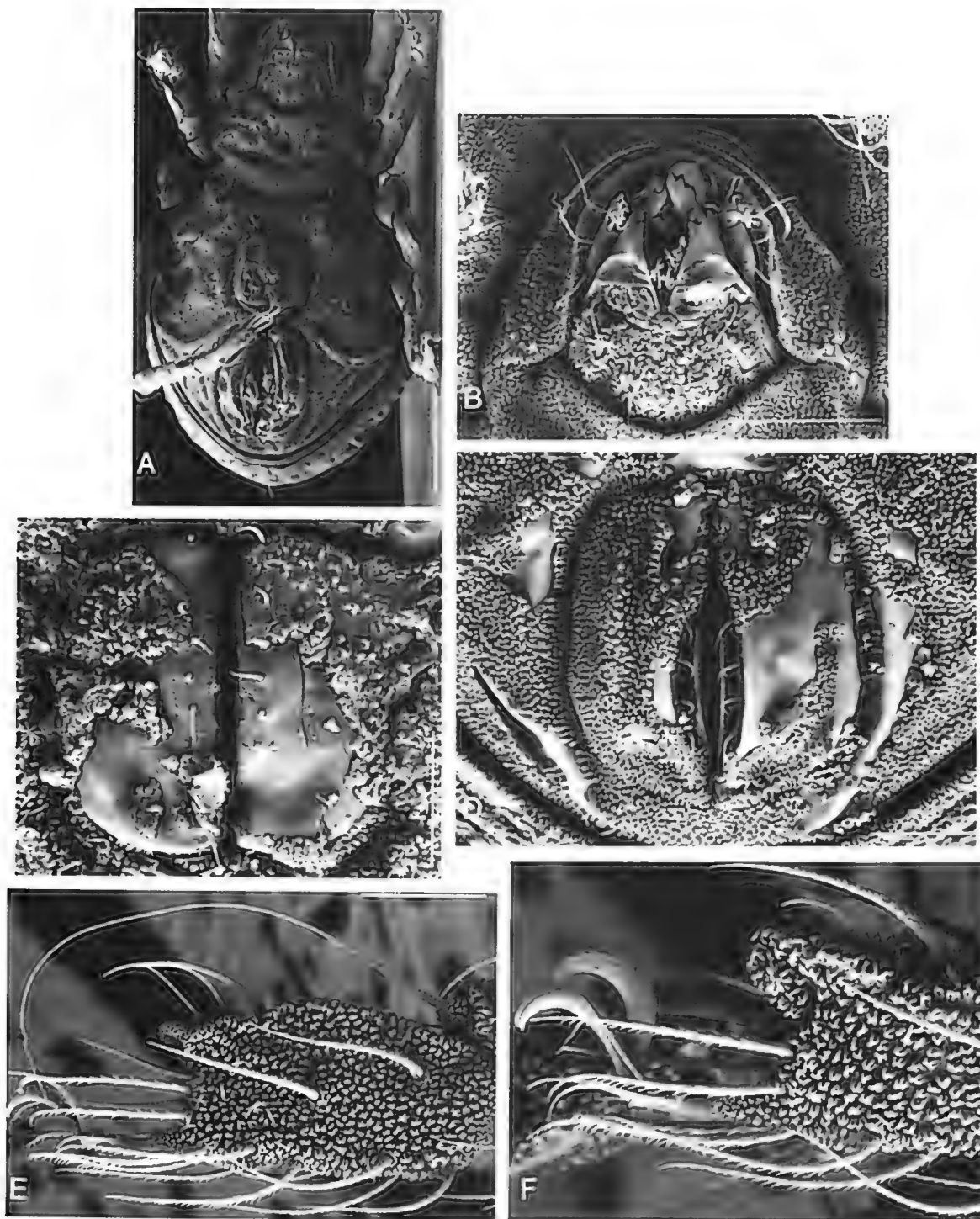


Fig. 11. *Pheroliodes lordhowensis* n.sp. A, body, ventral; B, subcapitulum; C, genital valves; D, anal valves; E, leg I tarsus, antiaxial; F, tarsus, detail. Scale bars: A = 200  $\mu$ m; B = 100  $\mu$ m; C–F = 50  $\mu$ m.

extremity of rim of tarsal cluster; femur of leg IV without large distoventral blade-like spine; stalk long.

### Description

ADULT: Differs from *P. springthorpei* in the following:

body longer, length 890  $\mu$ m, 900  $\mu$ m. Setae *le* and *ro*, notogastral setae and leg setae with thin coating of cerotegument. *Prodorsum*: transverse furrow anterior to it; transverse bar anterior to transverse furrow narrower mesally being relatively depressed in mesal zone anterior to transverse furrow carrying a small accessory

carina directed anteromesad (Fig. 10); mesal area immediately anterior and posterior to bar foveate; posterior margin of prodorsum between bothridia smoothly curved. *Notogaster*: ratio length:breadth 570:520; fissura *ia* and *ip* subparallel and *im* subperpendicular—oblique to sagittal plane. *Gnathosoma*: mentum without strong transverse carina anterior to setae *h*; rutella posteriorly with very concave flexure (Fig. 11B); pedipalp not studied. *Genitoanal region*: ventral plate not foveate but with cuticular thickenings lateral to anal valves (Fig. 11A,D); genitoanal chaetotaxy 7:1:4:3; setae *g1* and *g7* set near inner corners of genital valve, not in marginal notches (Fig. 11C); insertion of seta *ad1* at level of posterior margin of anal valve or slightly anterior to it, *ad2* adjacent to posterior 40% of valve, *ad3* adjacent to proximal 30% of valve, closer to valve than *ad2*. *Leg I*. Dorsal surface of tarsus forming a smoothly sloping crest with highest point proximal to *ft*" (Fig. 11E), *omega 1* and *omega 2* inserted similar level to *ft*", sclerotised ring surrounding opening of cavity containing undeveloped famulus paraxial to *omega 2*, rim around tarsal cluster produced distally into a prominent bulge (Fig. 11E); seta *tc*" inserted ventral and slightly distal to *omega 2*; setal barbs short; stalk long. *Leg II* tarsal cluster rim with very robust distal lip (Fig. 11F).

**Etymology.** The specific epithet derives from Lord Howe Island on which the species occurs.

**Distribution.** Lord Howe Island.

### *Pheroliodes monteithi* n.sp.

Figs 12, 13

**Type material.** Queensland: HOLOTYPE adult, QM S20028, Upper Brookfield, 27°29'S 152°52'E, rainforest litter, R. Raven, 19 March 1982. PARATYPE adults, QM S20052, SEM stub no. S/013 (ill.), Gold Creek, Brookfield, ca 27°30'S 152°55'E V.E. Davies & R. Raven, 17 Sept. 1980, 2 adults; QM S20083, SEM stub no. S/042 (ill.), Bulburin State Forest (barracks) via Builyan, 24°32'S 151°34'E, 600 m, rainforest, QM berlesate 826, G.B. Monteith, 16 Sept. 1989, 2 adults; QM S20033, Upper Brookfield, 27°29'S 152°52'E, with *Araucaria* litter, V. Davies and R. Raven, 3 March 1981, 4 adults; QM S20035, same site and collector data, 18 March 1981, 1 adult; QM S20158, Gold Creek, Brisbane, ca 27°28'S 153°01'E, litter, R. Raven and V.E. Davies, 23 June 1980, 3 adults; AM KS43828, same data, 3 adults; ANIC, same data, 3 adults; CNC, same data, 2 adults; FMNH, same data, 2 adults; SAMA, same data, 2 adults; ZMK, same data, 2 adults.

**Other material examined.** Queensland: QM S20115, 5 km E. of Benarkin at the foot of the Blackbutt Range, 25°52'S 152°12'E, rainforest, sieved litter, QM berlesate 522, J. Gallon and G. Thompson, 30 March 1983, 5 adults and 5 immatures; QM S20070, Bahrs Scrub, 27°44'S 153°10'E, litter, R. Raven, 30 April 1980, 19 adults; QM S20031, Upper Brookfield, 27°29'S 152°52'E, rainforest litter, R. Raven and V.E. Davies,

20 January 1982, 2 adults; QM S20146, Mount Brisbane, 27°05'S 152°32'E, R. Raven, 6 October 1979, 4 adults; AM KS46620 SEM stub no. S/052, Booloumba Creek, Conondale Ranges, 26°31'S 152°39'E, 520 m, rainforest litter, R. Raven, 13–18 May 1976, 2 adults; QM S20148, same data, 1 adult.

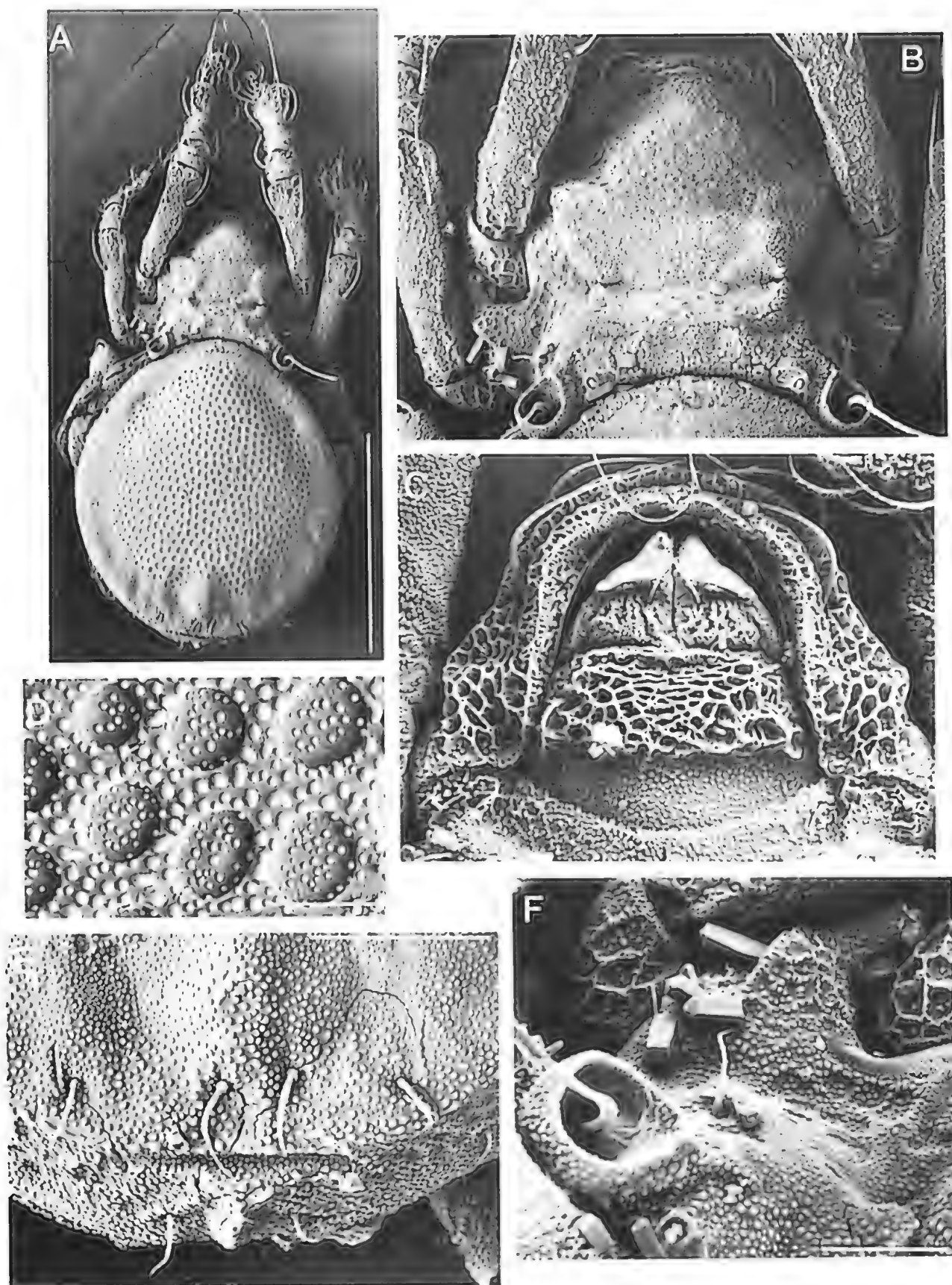
**Diagnosis.** Transverse bar in front of transverse furrow largely missing mesally and restricted to lateral cheek-like prominences; rostrum with reticulations of cerotegument; notogaster without anteromesal longitudinal carina or furrow, posteriorly not heavily folded; setae *lp* not oriented strongly towards midline; 3–5 pairs anal setae; dorsal surface of leg I tarsus extensively ribbed with cerotegument; tarsus of leg I with distal concavity; rim around tarsal cluster contributes to formation of distal concavity; famulus developed as short seta; femur of leg IV without large distoventral blade-like spine; stalk very short.

### Description

**ADULT:** Differs from *P. springthorpei* in the following: body much longer length 990 µm. *Cerotegument*: setae *ro* and *le*, notogastral setae and some leg setae with thin coating of cerotegument; rostrum with reticulate mass (Fig. 12B,C), mentum anteriorly with reticulate mass (Fig. 12C); tarsus 1 dorsally and paraxially with longitudinal crests of cerotegument. *Prodorsum*: transverse furrow without smaller mesal transverse furrow anterior to it; transverse bar anterior to transverse furrow virtually lacking mesally, restricted to a pair of lateral "cheek-like" prominences anterior to enantiophyses (Fig. 12A,B); most of prodorsum foveate; posterolateral carina on bothridium weak; sensillus relatively narrow; *ex* long (Fig. 12F); posterior margin of prodorsum smoothly curved. *Notogaster*: ratio length:breadth 690:610; fissura *ia* oblique and *im* and *ip* subparallel to sagittal plane; no anteromesal groove; setae *hl* short, close together, *pl* more widely separated (Fig. 12E). *Gnathosoma*: mentum with transverse carina with seta *h* embedded in strong cerotegument reticulations (Fig. 12C); pedipalp not studied. *Genitoanal region*: ventral plate largely foveate; chaetotaxy 7:1:3:3; setae *g7* set slightly anterior to inner corner of genital valve; *Leg I*. Apophysis on tibia overhanging about 0.2 tarsus; *omega 1* separated from *omega 2* by partition, famulus developed as short seta immediately distad of *omega 1* (Fig. 13B,C), seta *tc*" inserted distal to *omega 2*; distal recess for retracted ungual complex present, more complete than *P. concavus*; setal barbs short; stalk very short (Fig. 13B).

**Etymology.** The specific epithet acknowledges the substantial and long term effort of Dr Geoff Monteith in collecting and documenting the invertebrate fauna of Queensland and northern New South Wales.

**Distribution.** South-eastern Queensland.



**Fig. 12.** *Pheroliodes monteithi* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, subcapitulum; D, notogastral integument; E, notogaster, posterior region, dorsal; F, bothridium, setae *in* and *ex*, crystals an artefact. Scale bars: A = 500 µm; B = 200 µm; C, E = 100 µm; F = 50 µm; D = 20 µm.



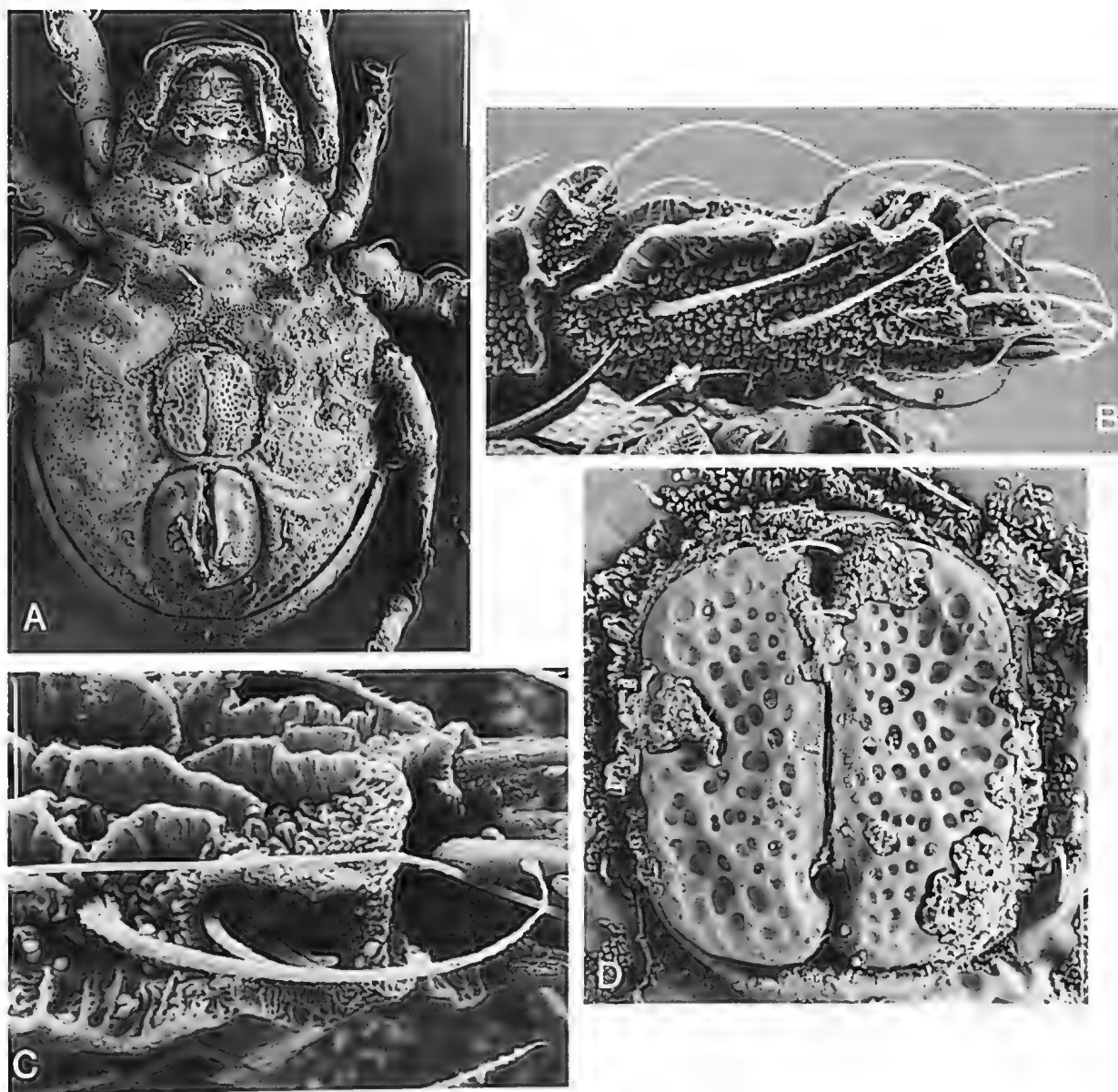


Fig. 13. *Pheroliodes monteithi* n.sp. A, body, ventral; B, leg I tarsus, antiaxial; C, tarsus (distal) dorsal; D, genital valves. Scale bars: A = 200  $\mu$ m; B,D = 50  $\mu$ m; C = 20  $\mu$ m.

***Pheroliodes sicarius* n.sp.**

Figs 14, 15

**Type material.** Queensland: HOLOTYPE adult. QM, Bulburin State Forest, via Builyan, 24°32'S 151°34'E, rainforest, litter and soil berlesate, G.S. Hunt, 6 July 1993. PARATYPE adults. QM, same data as holotype, 1 adult; AM KS43822, same data, one adult; AM KS46612 SEM stub no. S/265 (ill.), same data, 4 adults.

**Other material examined.** Queensland: QM S20084, Bulburin State Forest (barracks), via Builyan, 24°32'S 151°34'E, 600 m, rainforest, sieved litter, QM berlesate no. 826, G. Monteith, 16 Sep. 1989, 1 adult.

New South Wales: AM KS43823, Beaurie State Forest, 28°29'S 152°23'E, ca 700 m, litter under *Araucaria bidwillii*, ANIC berlesate 777, T. Weir and A. Calder, 15–17 February 1983, 5 adults; ANIC, same data, 5 adults.

**Diagnosis.** Transverse bar in front of transverse furrow essentially absent mesally, restricted to cheek-like lateral prominences; notogaster with faint anteromesal longitudinal furrow, posteriorly not heavily folded; setae *lp* not oriented strongly towards midline; 4–5 pairs anal setae; dorsal surface of leg I tarsus not extensively ribbed with cerotegument; tarsus of leg I without distal concavity; rim around tarsal cluster produced into a slight distal process which weakly overhangs distal part of tarsus; sclerotised ring surrounding opening of cavity containing

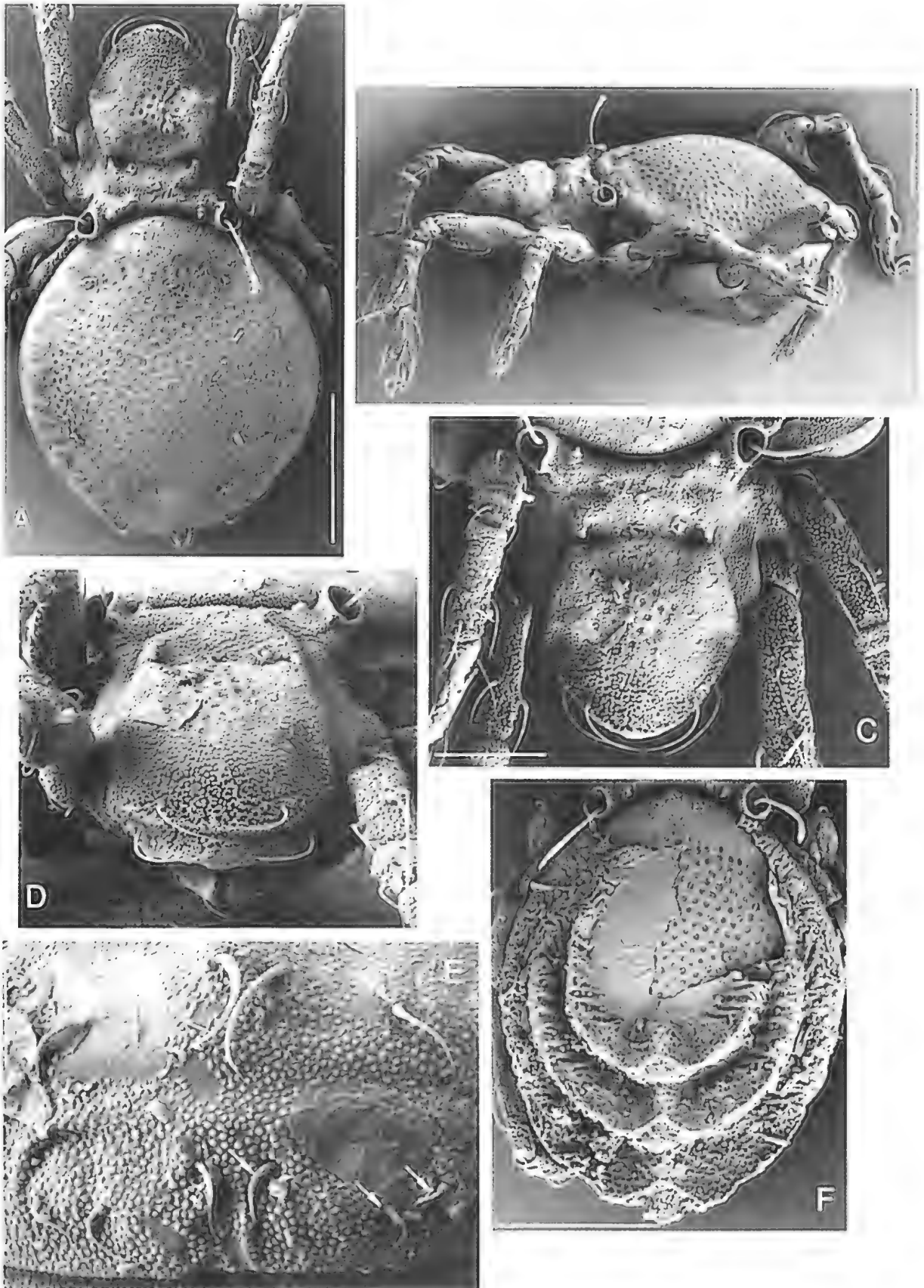


Fig. 14. *Pheroliodes sicarius* n.sp. A, body, dorsal; B, body, lateral; C, prodorsum, dorsal; D, prodorsum, frontal; E, notogaster, posterior, arrows left to right label setae *p1*, *p2*, *lp* and *p3* (conspicuous *h1* not arrowed); F, notogaster with scalps (partly removed). Scale bars: A,B,F = 200  $\mu$ m; C,D = 100  $\mu$ m; E = 50  $\mu$ m.

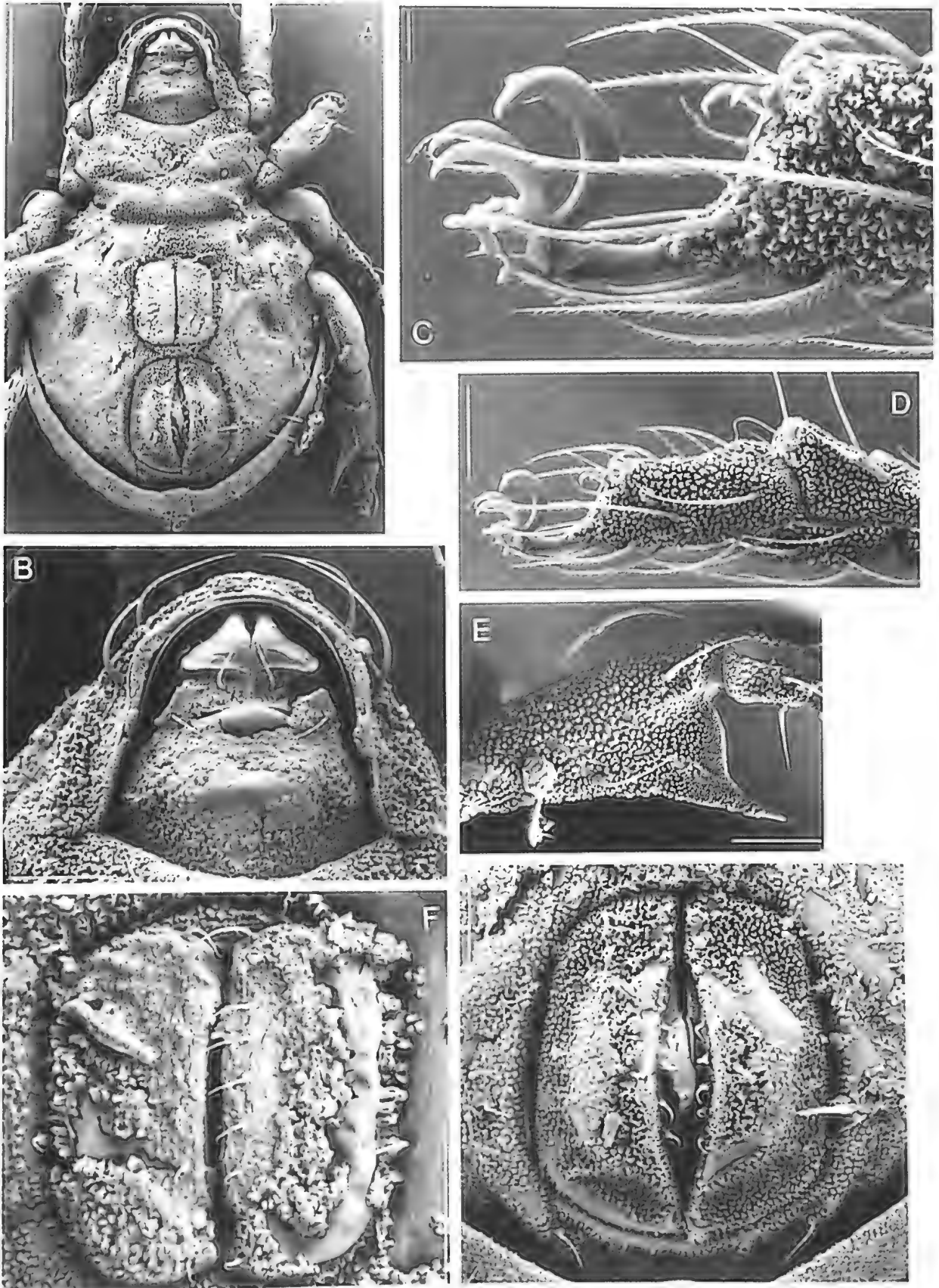


Fig. 15. *Pheroliodes sicarius* n.sp. A, body, ventral; B, subcapitulum; C, leg I tarsus, distal, antiaxial; D, tarsus and tibia (distal), antiaxial; E, leg IV femur, antiaxial; F, genital valves; G, anal valves. Scale bars: A = 200 µm; B, D–G = 50 µm; C = 20 µm.

undeveloped famulus not on distal extremity of rim of tarsal cluster; femur of leg IV with large distoventral blade-like spine; stalk long.

### Description

**ADULT:** Differs from *P. springthorpei* in the following: body length. Setae *ro* and *le*, notogastral setae and some leg setae with light covering of cerotegument. Transverse furrow without smaller mesal transverse furrow anterior to it; enantiophyses with well-developed posterior horn but vestigial anterior horn; transverse bar anterior to transverse furrow essentially absent mesally, restricted to cheek-like lateral prominences (Fig. 14C); mesal area of prodorsum anterior to transverse furrow foveate; setae *le* dorsolateral, distance between them about 0.75 distance between *ro*, posterolateral carina weak; sensillus very slender, expanding more gradually; margin of prodorsum between bothridia smoothly curved. *Notogaster*: exuvial scalps sometimes present (Fig. 14F). Foveae separated by about their diameter (Fig. 14F); fissura short, *ia* and *ip* subparallel and *im* subperpendicular to sagittal plane. Anteromesal groove if present weak; notogastral setae as in Fig. 14A,E. *Gnathosoma*: mentum with strong transverse carina in which setae *h* inserted (Fig. 15B); rutella posteriorly with slight concave flexure (Fig. 15B); pedipalp not examined. *Genitoanal region*: chaetotaxy 7:1:4–5:3; insertion of seta *ad1* at level of posterior margin of anal valve or slightly anterior to it, *ad2* inserted level with posterior half of genital valve at about 0.6 valve length, *ad3* adjacent to about 0.3 valve length (Fig. 15G). *Leg I*. Tarsal cluster situated distodorsally, *omega 2* situated ventrad to *omega 1*, seta *tc* situated ventrodorsad of *omega 2*, sclerotised ring surrounding opening of cavity containing undeveloped famulus situated paraxially between *omega 1* and 2, stalk long (Fig. 15C). *Leg IV*. Femur with very strong distoventral blade-like spine (Figs 14B, 15E).

**Etymology.** The specific epithet is Latin for “assassin” and refers to the blade-like spine on femur 4.

**Distribution.** Far northern New South Wales to southern Queensland.

### *Pheroliodes transversus* n.sp.

Fig. 16

**Type material.** New South Wales/Australian Capital Territory: HOLOTYPE adult. AM KS43818, beside Federal Highway, just N. of Canberra on NSW/ACT border, 35°23'S 149°23'E, open forest beneath *E. viminalis*, berlese extraction of leaf litter, G.S. Hunt, 10 May 1992. PARATYPE adults. AM KS46606 SEM stub no. S/076 (ill.), same data as holotype, 2 adults; AM KS46607 SEM stub no. S/077 (ill.), same data, 3 adults; AM KS43819, same data, 3 adults; AM KS43820, same data, 1 adult with scalp; ANIC, same data, 2 adults; CNC, same data, 1 adult; FMNH, same data, 1 adult; QM, same data, 1 adult; ZMK, same data, 1 adult.

**Other material examined.** New South Wales: AM KS46608 SEM stub no. S/184, Granite Hills, 28 km S. of Tenterfield by the New England Highway, 29°17'S 151°58'E, berlese extraction of litter, G.S. Hunt, 10 July 1992, 3 adults; AM KS43821, same data, 1 adult.

South Australia: AM KS46609 SEM stub no. S/226 (ill.), 86 km S of Meningie, ca 36°22'S 139°45'E, leaf litter in sandy soil, ANIC berlesate 74, E.B. Britton, 30 April 1968, 4 adults; AM KS46610 SEM stub no. S/209, 4.8 km W. of Parilla, 35°18'S 140°39'E, Mallee, ANIC berlesate 184, R.W. Taylor, 12 January 1970, 1 adult; AM KS46611 SEM stub no. S/220, 3.2 km W. of Sherlock, 35°19'S 139°46'E, Mallee, ANIC berlesate 182, R.W. Taylor, 12 January 1970, 4 adults; ANIC, same data, 6 adults.

**Diagnosis.** Transverse bar in front of transverse furrow narrow mesally with transverse anterior edge; notogaster with strong anteromesal longitudinal furrow; posteriorly not heavily folded; setae *lp* oriented strongly towards midline; 3–4 pairs anal setae; dorsal surface of leg I tarsus not extensively ribbed with cerotegument; tarsus without distal concavity, rim around tarsal cluster produced into small process which overhangs distal part of tarsus; leg I with sclerotised ring surrounding opening of cavity containing undeveloped famulus on distal extremity of rim of tarsal cluster; femur of leg IV without large distoventral blade-like spine; stalk long.

### Description

**ADULT:** Differs from *P. springthorpei* in the following: Body length 600 µm. *Prodorsum*: transverse bar anterior to transverse furrow depressed posteromesally (Fig. 16B); without obvious foveae; posterior margin of prodorsum between bothridia more curved. *Notogaster*: scalps occasionally carried. Ratio length:breadth 460:340; foveae more widely separated; fissura *ia* oblique, *im* subperpendicular and *ip* subparallel to sagittal plane, *ip* long; strong anteromesal groove; setae *lp* strongly curved mesad (Fig. 16A,F). *Gnathosoma*: mentum setae *h* inserted in strong transverse carina; pedipalp not studied. *Leg I*. Solenidia *omega 1* and 2 inserted at same dorsal level as *fi* (Fig. 16G); stalk long. *Leg II* tarsal cluster rim with very small distal lip.

**Variation.** The Tenterfield specimen resembles *P. springthorpei* in having a short stalk supporting the claw complex on leg I and in having *omega 1* and 2 at a more ventral level than *fi*.

**Etymology.** The specific epithet is Latin for “transverse” and refers to the transverse orientation of notogastral setae *lp*.

**Distribution.** New South Wales and South Australia. From the limited data available, the species seems to occur west of the Great Dividing Range.



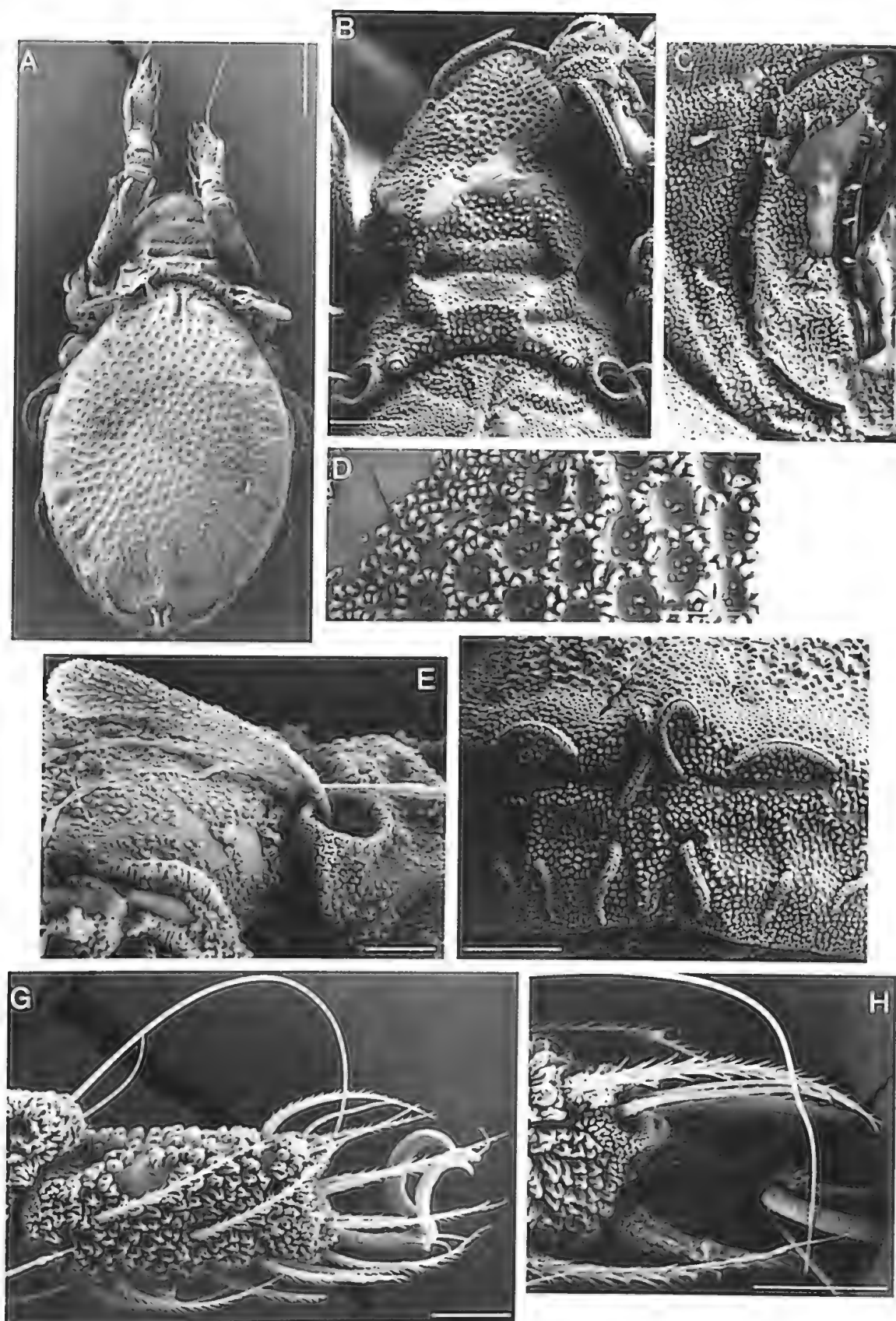


Fig. 16. *Pheroliodes transversus* n.sp. A, body, dorsal; B, prodorsum, dorsal; C, anal valve; D, notogastral integument and fissura *im*; E, bothridium, sensillus and seta *in*, lateral; F, notogaster, posterior; G, leg I tarsus, antiaxial; H, tarsal cluster, dorsolateral. Scale bars: A = 100 µm; B,C,F = 50 µm; D,E,G,H = 20 µm. A-D,F-H = Canberra; E = Meningie.

*Octoliodes* Paschoal, 1987

*Octoliodes* Paschoal, 1987: 377; 1989b: 187.—Balogh & Balogh, 1992:47.

**Diagnosis.** Cerotegument in form of rounded cushions; prodorsum with enantiophyses and seta *ex*, strongly reticulate, with smoothly rounded contours anterior to transverse furrow, without clearly differentiated transverse bar; sensillus short, with short twisted petiole and stout blade; notogaster with or without scalps; notogaster continuously convex, without depressed area inside margin; notogaster foveate centrally, without foveae in zone around its margins; notogastral setae arising from tubercles; epimera 2 and 3 with opposing horns laterally; epimeral chaetotaxy 3:1:3:3; genitoanal chaetotaxy 7:1:3:3; ventral plate may be extensively folded; legs reticulate; tarsus without distal recess or concavity; tarsus of leg IV without iter al setae.

*Octoliodes robustus* (Hunt & Lee) n.comb.

Figs 17, 18

*Pheroliodes robustus* Hunt & Lee 1995: 240, figs 6A,9,10.

**Type material.** South Australia: HOLOTYPE female: SAMA, N1993681, Piccaninnie Ponds Conservation Park, 38°03'S 140°57'E, coastal closed scrubland, berlesate soil, litter, sparse grass under coastal wattle (*Acacia sophorae*), D.C. Lee, 3 August 1974. PARATYPE female: AM KS46641 SEM stub S/200, same data as holotype.

**Additional records.** New South Wales: AM KS46621, SEM stub no. S/334, Slaven Cave via Wallarawang, 33°24'S 150°00'E, open sclerophyll forest, berlesate litter and moss, G.S. Hunt, 20 May 1994, 1 adult; AM KS46622, SEM stub no. S/294, Dorrigo, 30°20'S 152°43'E, 1 adult; AM KS43829, same data, 1 adult; AM KS46623, SEM stub no. S/297, Allyn River Park via Upper Allyn, ca. 32°10'S 151°30'E, subtropical rainforest, berlesate bark scraped from trees, G.S. Hunt, 5 October 1993, 4 adults; AM KS43830, same data, 7 adults and 6 nymphs possibly of this species; AM KS46624 SEM stub no. S/434, same data, 3 adults; AM KS46625 SEM stub no. S/300, Macquarie Pass, 8 km E. of Robertson, 800 m, 34°35'S 150°38'E, laurel-sassafras rainforest, ferns, L. Masner, Agriculture Canada, 8 February 1984, 1 adult; CNC, same data, 1 adult; CNC, New England National Park, 30°29'S 152°25'E, 1600 m, *Nothofagus moorei* forest, ferns, L. Masner, Agriculture Canada, 12 February 1984, 1 adult; AM KS46626 SEM stub no. S/104, Allyn River, Chichester State Forest, 32°12'S 151°26'E, rainforest leaf litter, ANIC berlesate 747, T. Weir and A. Calder, 10–11 November 1981, 1 adult; AM KS46627 SEM stub no. S/423, same data, 1 adult.

Tasmania: AM KS46628, SEM stub no. S/273, Mount Michael, 41°10'S 148°00'E, pyrethrum knock-down from tree, R. Coy, 28 November 1989, 4 adults; ANIC, same data, a large series of adults and nymphs; AM KS43831, same data, 5 adults; SAMA, same data, 5 adults; QM, same data, 5 adults; FMNH,

same data, 5 adults; CNC, same data, 5 adults; ZMK, same data, 5 adults; AM KS46629 SEM stub no. S/277, Rivaux River, 43°10'S 146°39'E, Huon pine tree trunk, pyrethrum knock down, P. Greenslade, 20 December 1988, 3 adults; ANIC, Big Sassy Creek, 42°08'S 147°54'E, 400 m, rainforest site 2, pyrethrum knockdown, P. Greenslade, 12 May 1989, 5 adults; AM KS46630 SEM stub no. S/317 (ill.), same data, 4 adults; AM KS46631, SEM stub no. S/311 (ill.), Big Sassy Creek, 42°08'S 147°54'E, 400 m, rainforest site 1, sassafras, pyrethrum knockdown, H. Mitchell, 17 May 1989, 4 adults; AM KS46632, SEM stub no. S/312 (ill.), Big Sassy Creek, same site details, moss on log, H. Mitchell, 17 May 1989, 1 adult; AM KS46633, SEM stub no. S/313 (ill.), Big Sassy Creek, same site details, pyrethrum knockdown, J. Diggle, 12 May 1989, 4 adults; AM KS46634, SEM stub no. S/314 (ill.), Big Sassy Creek, same site details, moss, H. Mitchell and J. Diggle, 12 May 1989, 1 adult; ANIC, Mount Michael, 41°10'S 148°00'E, in moss, A. Trumbull-Ward, 11 June 1990, 12 adults; ANIC, Mount Victoria, 41°20'S 147°49'E, 900 m, pyrethrum knockdown from trees, H. Mitchell and R. Coy, 25 November 1989, very large series of adults and nymphs; AM KS43832, same data, 4 adults.

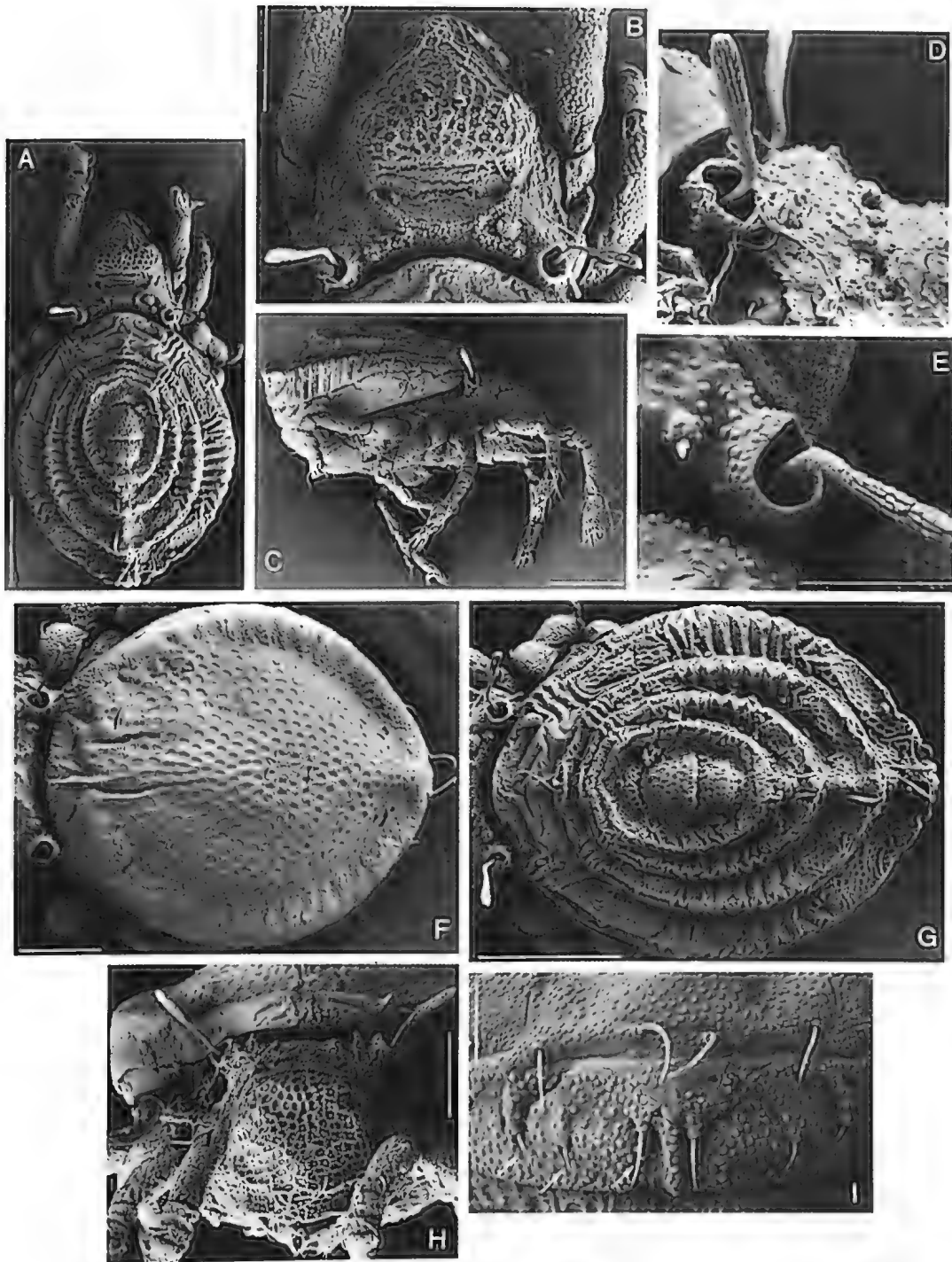
Victoria: AM KS43833, Turtons Pass, Otway Ranges, ca 38°33'S 146°15'E, on *Olearia agrophylla* (Musk Daisy), V. Barnes, 16 March 1993, 1 adult; AM KS46635 SEM stub no. S/231, Phillips Track, Young Creek crossing 0.5 km N. of Triplet Falls, Otway Ranges, 38°40'S 143°29'E, moss from *Nothofagus cunninghami*, G. Milledge, P. Lillywhite, C. McPhee and B. Van Praagh, 11 December 1991, 2 adults; AM KS46636, SEM stub no. S/232, same data, 1 adult; AM KS43834, same data, 1 adult.

## Additional description

**ADULT:** Dark brown; exuvial scalps as in Fig. 17G; prodorsum divided into two main fields—strongly reticulate anterior to transverse furrow, very weakly so posterior to it; mentum without transverse carina near setae *h*; ventral plate and anal and genital valves extensively folded (Fig. 18A); tarsal cluster of leg I distodorsal; *omega* 1 and 2 close together, opening of cavity containing undeveloped famulus directed distad, ventral to solenidia (Fig. 18F); stalk short. Leg II tarsal cluster rim lacking distal lip.

**Variation.** The eastern Australian and Tasmanian specimens have a less broad terminal expansion to the sensillus with a less strong transition from petiole to lamina compared with the type material from South Australia (cf., Fig. 17D and Hunt & Lee, 1995, fig. 15C). The specimen collected outside Slaven Cave, New South Wales, has a relatively longer sensillus and a smoother notogaster.

**Comments.** This species differs from other Australian Pherolioidae in the strongly reticulate prodorsum with closely spaced alveoli-foveae, the intensively folded ventral plate, notogastral setae arising from tubercles, the lack of a distal lip to the rim surrounding the tarsal cluster, the orientation of the opening to



**Fig. 17.** *Octoliodes robustus* (Hunt & Lee) A, body, dorsal; B, prodorsum, dorsal; C, body, lateral; D, bothridium, sensillus and setae *in* and *ex*, lateral; E, bothridium and seta *in*, dorsal; F, notogaster, dorsal, without scalps; G, with scalps; H, prodorsum, frontal; I, notogaster, posterior, arrows right to left label setae *p1*, *p2* and *p3*. Scale bars: A,C,G = 200  $\mu$ m; B,F,H = 100  $\mu$ m; D,E,I = 50  $\mu$ m. A–I = Big Sassy Creek.

the cavity containing the famulus, and the shape of the sensillus. It appears very close to *Octoliodes luteomarginata* (Hammer, 1966) from New Zealand, the type species for the genus *Octoliodes* Paschoal. Accordingly, it is now placed in this genus. It differs from the New Zealand species in habitually carrying scalps. *Octoliodes robustus* exhibits the opposing

horns on epimera 2 and 3 suggesting its close relationship with Australian *Pheroliodes*.

**Distribution.** South Australia at type locality; Tasmania and eastern mainland Australia south of Dorrigo, New South Wales.



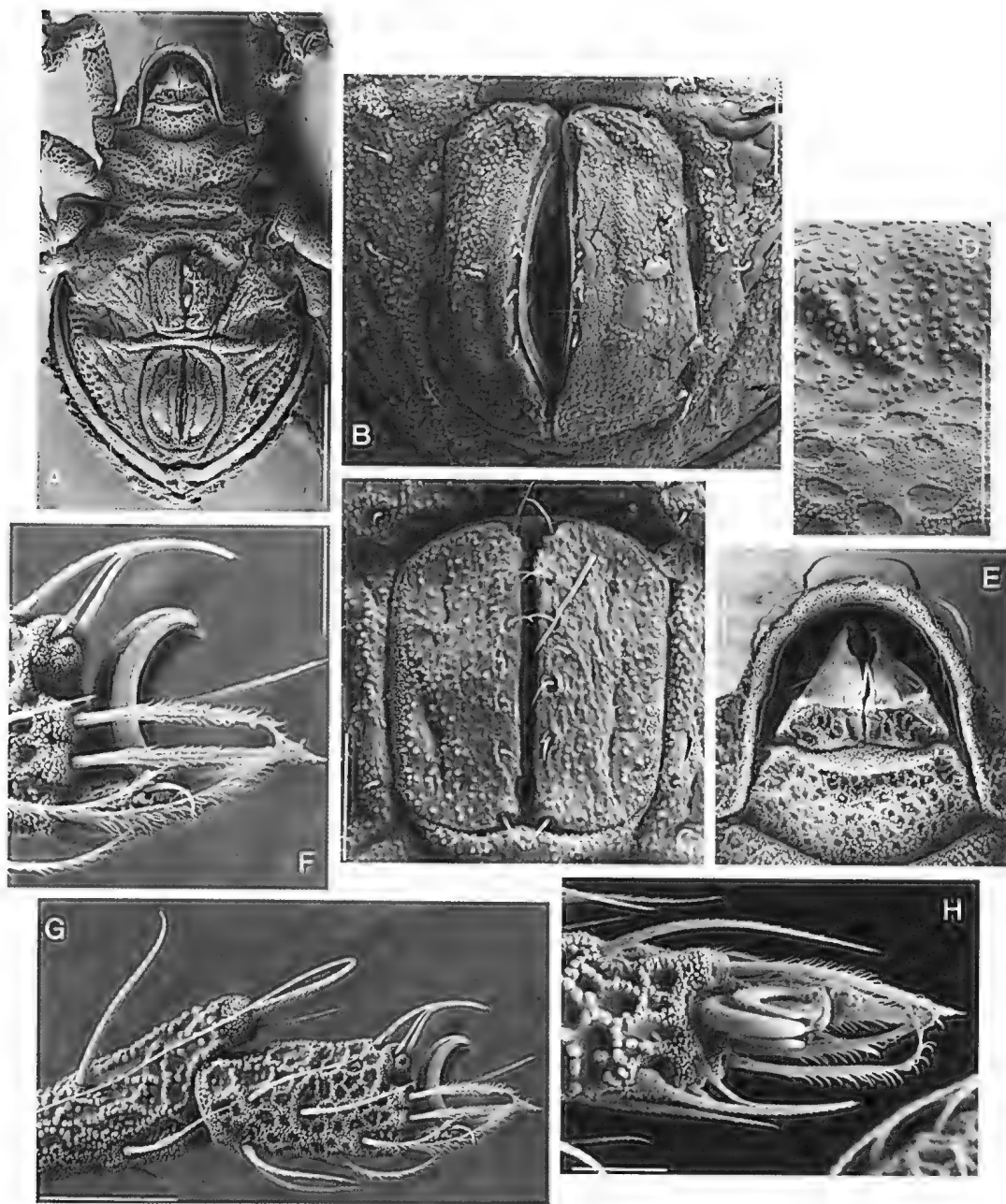


Fig. 18. *Octoliodes robustus* (Hunt & Lee). A, body, ventral; B, anal valves; C, genital valves; D, notogastral integument and fissura *im*, lateral at top; E, subcapitulum; F,H, leg I tarsus (distal), antiaxial and dorsal; G, tarsus and tibia, antiaxial. Scale bars: A = 200  $\mu$ m; B–E,G = 50  $\mu$ m; F,H = 20  $\mu$ m. A–H = Big Sassy Creek.

### *Neonooliodes* n.gen.

**Type species.** *Neonooliodes ceroplastes* n.sp.

**Diagnosis.** Prodorsum with deep transverse furrow with enantiophyses; seta *ex* present; prodorsum, venter and legs strongly reticulated with cerotegument; bothridium against notogaster; sensillus with long petiole expanding gradually into lamina; notogaster not continuously convex, with depressed area inside margin; notogaster alveolate-reticulate over entire surface, including margins; distal recess of tarsus I not roofed by distal lip of rim of tarsal cluster; tarsus of leg IV without iterl setae.

### Description

Medium sized plateremaeoid mites (about 650–750  $\mu$ m); notogaster with exuvial scalps; prodorsum, venter and legs strongly reticulated with cerotegument reflecting a more subdued underlying relief of integument; prodorsum with deep transverse furrow with enantiophyses; seta *ex* present; seta *in* small and arising from apophysis; bothridium with weak posterolateral carina; bothridium abutting notogaster but posterior wall not depressed; sensillus with long petiole and delicate blade (though less broad than *Pedrocortesella*), tuberculate; notogaster not rising continuously from margin to centre but with depressed area inside margins; alveolate-reticulate over

entire surface, including margins, not foveate; without longitudinal anteromesal furrow; with mesal furrow ventral to setae *p1* on posterior flank; 5 pairs of notogastral setae, setae *p2* and *p3* situated low on the posterior flank at the same general level as setae *p1*; *lp* situated very close to fissura *ip*; *lm* (*r3*) absent; pedipalp tarsus with short apophysis supporting seta *acm*, seta *l''* with barbs; epimera 2 and 3 without obvious opposing horns laterally; epimeral chaetotaxy 2(?)1:3:3; 7 pairs of genital setae forming straight file near inner margin of valves; 1 aggenital seta lateral to genital valve; 3–4 anal setae on either valve, sometimes asymmetrical in number, 3 adanal setae, *ad1* usually inserted lateral to posterior 20% of anal valve; *ft''* of tarsus I not enclosed in same collar as solenidia, opening of cavity containing undeveloped famulus directed dorsad; distal recess of tarsus not roofed by distal lip of rim of tarsal cluster; claw stalk short; tarsus of leg IV without iter setae.

**Comments.** The type species bears at least a superficial similarity to *Nooliodes glaber* (J. Balogh, 1962) which Paschoal (1989a) places in a separate family, Noolioididae, on what, I believe, are genus-level characters. The Australian species differs from the Madagascan in having seven pairs of genital setae in a straight file, rather than eight pairs including one offset, and in having the pair of aggenital setae lateral to the genital valves, rather than posterior. The Australian species has a faint reticulation pattern on the notogaster, the Madagascan species is described as being smooth. Scalps are habitually carried by adults of the Australian species; it is predicted that the Madagascan species, because of its smooth (? faintly patterned) notogaster, will also be shown to habitually carry scalps.

Only two setae were seen on epimeron I; a third (most lateral) seta may have been obscured.

**Etymology.** The generic name emphasises the similarity of this species to the Madagascan genus *Nooliodes* Paschoal. Gender is masculine.

### *Neonooliodes ceroplastes* n.sp.

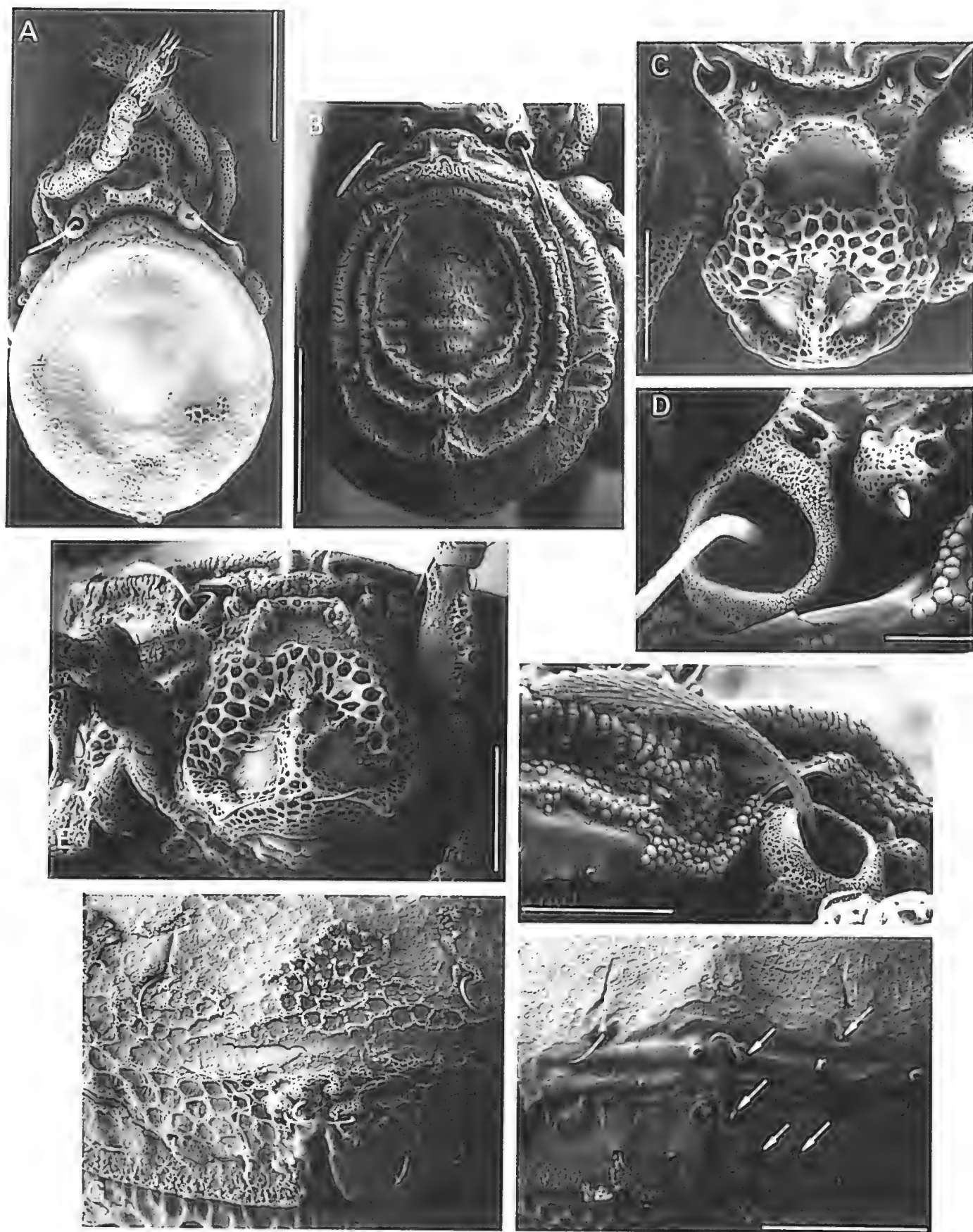
Figs 19–22

**Type material.** New South Wales: HOLOTYPE adult. AM KS43835, West Head, Ku-ring-gai Chase National Park, Challenger Track, ca 33°35'S 151°18'E, remnant gully rainforest, berlesate, J. Thompson and M. Gray, 24 November 1992. PARATYPE adults. AM KS46637 SEM stub no. S/196 (ill.), same data as holotype, 6 adults; AM KS46638 SEM stub no. S/198, same data, 4 adults; AM KS43836, same data, 26 adults; AM KS43837, Mount Tomah, 33°33'S 150°25'E, closed forest, berlesate litter and top soil, red basalt soil, G.S. Hunt, 21 June 1992, 4 adults; ANIC, same data, 3 adults; FMNH, same data, 2 adults; QM, same data, 2 adults; SAMA, same data, 2 adults; CNC, same data, 1 adult; AM KS46639 SEM stub no. S/125, same data, 4 adults; AM KS46640 SEM stub no. S/144 (ill.), same data, 3 adults.

**Diagnosis.** As for genus.

### Description

**ADULT:** Body dark brown, length 650 µm, 730 µm. **Cerotegument:** body (except notogaster) and legs covered with thick reticulate deposits of cerotegument reflecting underlying structure of integument (Figs 19C, 20E, 21C); notogaster (after scalps removed) with stellate deposits on reticulations uniting to give a "stitched" appearance (Fig. 21B). Anterior margin of notogaster with closely spaced cushions of cerotegument (Fig. 19F). Setae *ro* and *le*, notogastral setae and leg setae without conspicuous cerotegument. **Prodorsum:** transverse bar anterior to transverse furrow with thick deposit of reticulate cerotegument with a mesal extension connecting to the strong reticulate carina between setae *le* and *ro* (Fig. 19E); setae *le* dorsolateral, distance between them about 0.66 distance between *ro*, *ro* ventrolateral; pedotectal tooth smooth, strongly curved anteriad; bothridium abutting notogaster (Fig. 19D), rim subcircular, anterolateral rim much lower than posterolateral rim, posterolateral carina weak; sensillus long, expanding gradually to blade from slightly above bothridial rim, tuberculate from bothridial rim (Fig. 19F); *in* arising from strong apophysis at edge of dorsosejugal suture and separated by <0.5 bothridial diameter from bothridial wall, small, acute, proximally with cerotegument (Fig. 19D–F); *ex* anterolateral to base of bothridium, very small, largely covered with cerotegument granules; posterior margin of prodorsum between bothridia strongly curved. **Notogaster:** exuvial scalps habitually carried (Fig. 19B). Ratio length:breadth 510:430; notogaster with convex central area surrounded by oval-shaped depression inside the margin (Fig. 19A); entire surface alveolate-reticulate (Fig. 19A,G); fissura *ia* and *ip* subparallel and *im* subperpendicular to sagittal plane. No anteromesal groove (Fig. 19A), posterior flank with groove ventral to setae *p1* (Fig. 19G). Setae *h1* short and twisted mesad, close together and inserted on posterior margin; setae *lp* inserted very close to fissura *ip* (Figs 19G,H; 22A); *p1* inserted close together ventral to *h1*; *p2* and *p3* situated lower on posterior flank (Figs 19G; 22B). **Gnathosoma:** mentum without strong transverse carina immediately anterior to or supporting setae *h*; rutella posteriorly convex (Fig. 20G); length of apophysis supporting pedipalp tarsal seta *acm* <0.5 seta length, solenidion reaching above base of *acm*, seta *l''* strongly barbed and set ventrad on antiaxial surface (Fig. 20B,C). **Genitoanal region:** ventral plate strongly foveate-reticulate with cuticular thickening surrounding anal valves with an oblique extension towards leg IV. Anal and genital valves foveate-reticulate, each anal valve with a longitudinal groove parallel to and close to the inner margin (Fig. 20D); chaetotaxy 7:1:3–4:3; setae *g1* and *g7* set in marginal notches in inner corners of genital valve, other setae in straight file close to lip of valve (Fig. 20F); seta *ag* close to lateral margin of valve; anal setae may be asymmetrical in number; insertion of seta *ad1* at level of posterior margin of anal valve, *ad2* inserted near posterolateral corners of valve, *ad3* adjacent to proximal 40% of valve (Figs 20D; 22B). **Leg I.**



**Fig. 19.** *Neonooliodes ceroplastes* n.sp. A, body, dorsal; B, notogastral scalps, dorsal; C,E, prodorsum, dorsal and frontal; D, bothridium and seta *in*, dorsal; F, bothridium, sensillus and seta *in*, laterofrontal broken; G,H, notogaster, posterior, arrows left to right label setae *pl*, *hl*, *p2*, *p3* and *lp* (all except *hl* broken). Scale bars: A,B = 200 µm; C,E,H = 100 µm; F,G = 50 µm; D = 20 µm. A–G = Ku-ring-gai Chase; H = Mount Tomah.

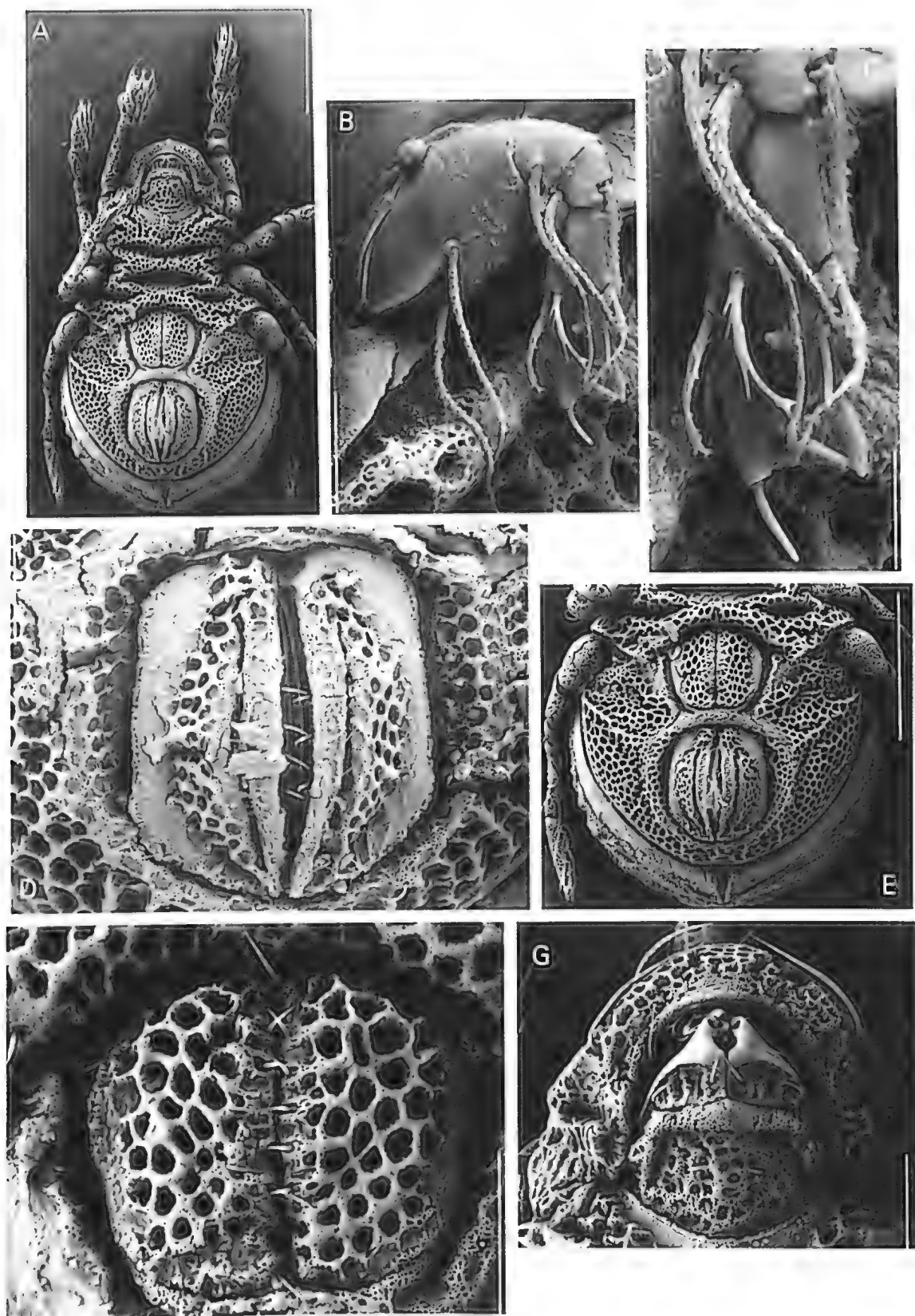
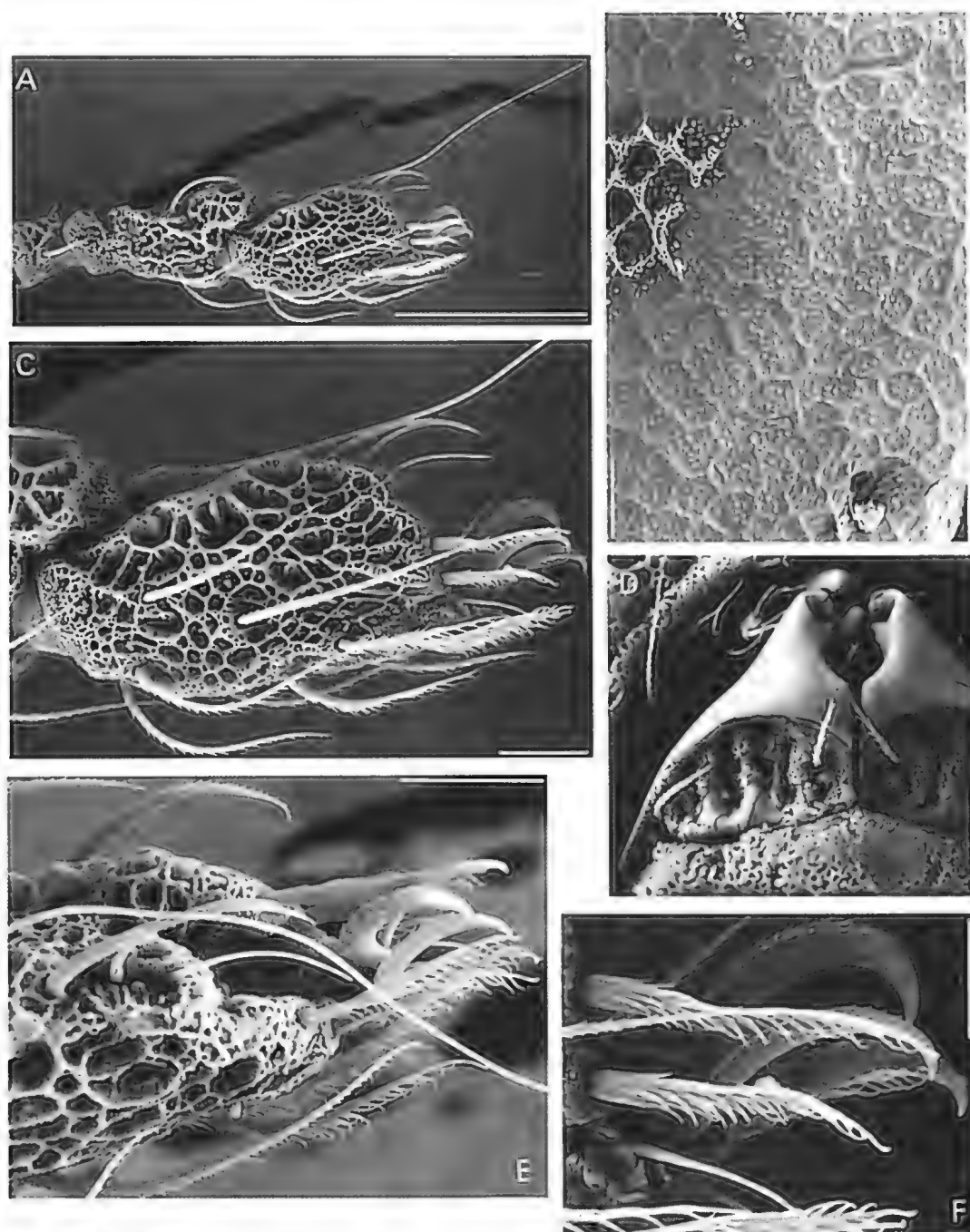


Fig. 20. *Neonooliodes ceroplastes* n.sp. A, body, ventral; B, pedipalp antiaxial; C, pedipalp tarsus, antiaxial; D, anal valves; E, ventral plate and anal and genital valves; F, genital valves; G, subcapitulum. Scale bars: A,E = 200  $\mu$ m; D,F,G = 50  $\mu$ m; B = 20  $\mu$ m; C = 10  $\mu$ m.





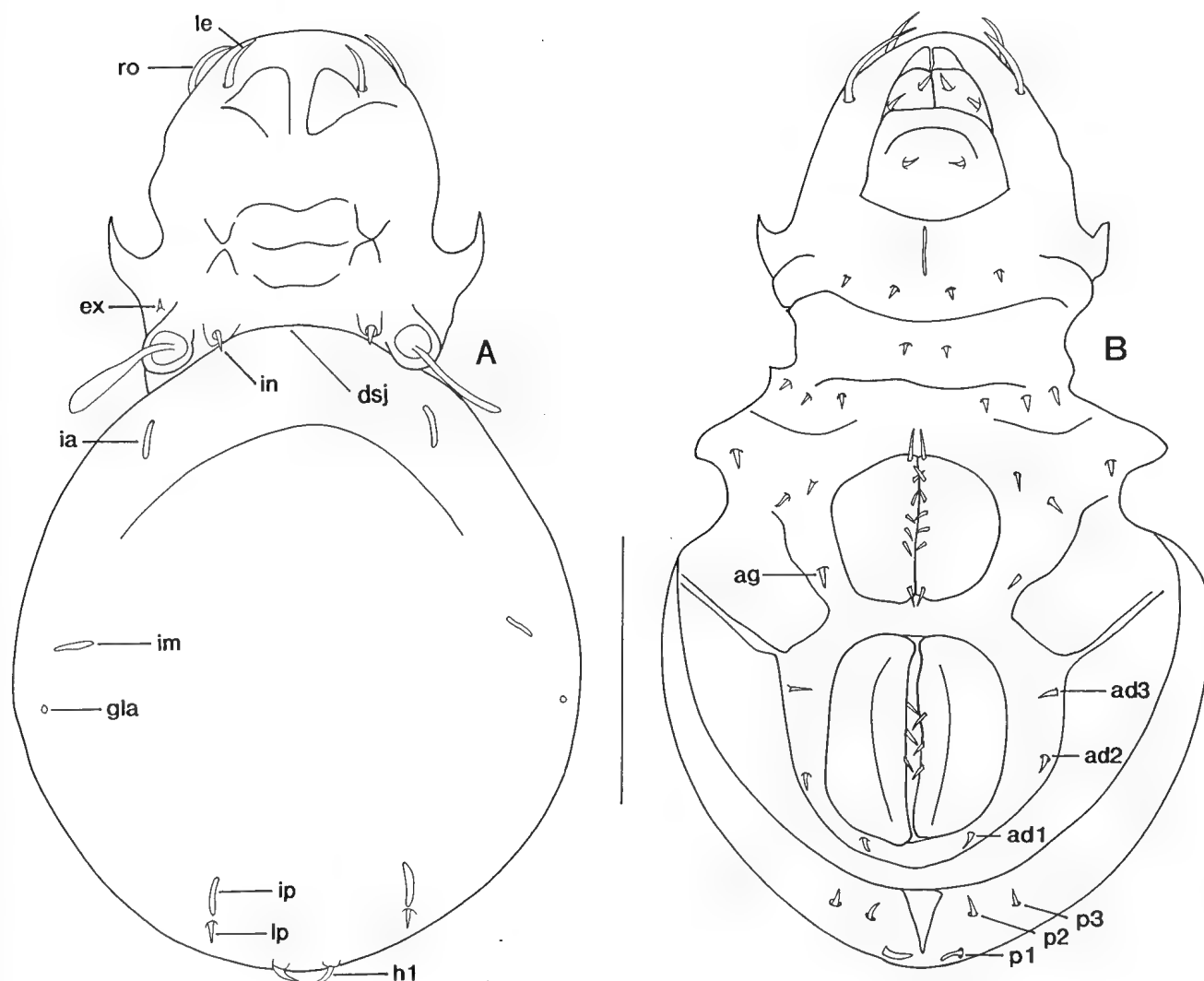
**Fig. 21.** *Neonooliodes ceroplastes* n.sp. A, leg I tibia and tarsus, antiaxial; B, notogastral integument, fissura *im* and *gla*; C, tarsus 1, antiaxial; D, subcapitulum; E, F, distal part of tarsus 1, dorsal and antiaxial. Scale bars: A = 100  $\mu$ m; B–E = 20  $\mu$ m; F = 10  $\mu$ m. A, C–F = Ku-ring-gai Chase; B = Mount Tomah.

Strongly reticulate (Fig. 21A). Apophysis on tibia overhanging about 0.2 tarsus; seta *ft* situated at highest point and arching gently distad, *omega* 1 and 2 inserted at similar level distal to it, sclerotised ring surrounding opening of cavity containing undeveloped famulus between *omega* 1 and 2 but paraxial to them (Fig. 21E), setae *tc* and *it* short (Fig. 21C), inserted distal to *omega* 2; deep distal recess presumably for receiving retracted claw complex (Fig. 21E), recess not roofed by distal lip

of rim of tarsal cluster; stalk essentially absent (Fig. 21F). Leg II tarsal cluster rim lacking distal lip.

**Etymology.** The specific epithet is Greek for “modeller in wax” and alludes to the intricate patterns of cerotegument on body and legs.

**Distribution.** New South Wales: Sydney area.



**Fig. 22.** *Neonooliodes ceroplastes* n.sp. A, body, dorsal (scalps removed); B, body, ventral. Scale bar = 200  $\mu$ m. *dsj* = dorsosejugal suture; *ro* = rostral seta; *le* = lamellar seta; *ex* = exobothridial seta; *in* = interlamellar seta; *h1*, *lp*, *p1*, *p2*, *p3* = notogastral setae; *ag* = aggenital seta; *ad1*, *ad2*, *ad3* = adanal setae; *ia*, *im*, *ip* = fissures; *gla* = opening of lateral opisthosomal gland. (N.B., integumental microsculpture not shown in SEMs.)

## General Discussion

As discussed by Hunt & Lee (1995) and Hunt (1996a), *Pedrocortesella* is now accepted as a junior synonym of *Pheroliodes*. Contrary to Paschoal (1989b), *Pheroliodes* (and other pherolioid genera) does possess a strong transverse furrow on the prodorsum in a similar position to that in *Pedrocortesella*. The two genera also possess a posterolateral process on the bothridium and an absence of iteral setae from the tarsus of leg IV. They are evidently closely related, probably more so than their placement in separate families by Paschoal (1989b) would suggest. The differences, which include presence or absence of prodorsal enantiophyses, the contour of

the notogaster, the disposition of notogastral setae, and the number of anal setae, seem to be relevant at the generic level. However, as discussed by Hunt (1996a,c), a family level revision of the Plateremaeoidea should await a phylogenetic analysis.

A number of characters in Australian species placed in *Pheroliodes* differ from the South American type species described by Grandjean (1964): more elongate form of the sensillus, a tendency to form a distal lip to the rim of the tarsal cluster, enantiophyses on epimera 2 and 3, and a tendency for anal neotrichy. These characters may warrant separate generic status for the Australian species, but a more conservative approach is adopted here pending a phylogenetic analysis.

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